The SCIENTIFIC FEEDING of CHICKENS

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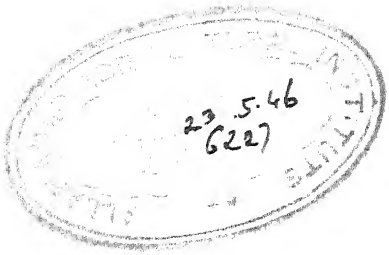

PREFACE

The compilation of the data in this little book was begun in 1936, and as new data became available they were added. Often it was necessary to make extensive changes in the original compilation, especially in the case of the data on the vitamin content of feedstuffs. Many such changes were made during December, 1939, in an effort to bring the compilation up to date. Other changes undoubtedly will be necessary as more dependable information is acquired. For this reason the writer will appreciate receiving all new data on the nutritive requirements of chickens and the nutritive properties of feedstuffs. Also, if errors are found in the text or tables the writer wants them called to his attention, because if this book is to be truly useful the information it contains must be as accurate and dependable as it is possible to make it.

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THE SCIENTIFIC FEEDING OF CHICKENS

Until recent years the feeding of chickens was an art rather than a science. It was based on systems of rules and methods which were expressions of the experience of those who had been most successful in rearing chickens. Often it was not known why the application of a certain rule or method tended to give good results; but the fact remained that good results were likely to be obtained if the rule or method was followed. However, the scientific study of poultry nutrition has done much to change the situation. Enough knowledge in this field has now been accumulated to place the feeding of chickens on a scientific basis; nevertheless, because much of this knowledge is not readily available to the practical poultryman, the feeding of chickens is still nearly as much an art as it is a science.

The purpose of this little book is to bring together, and thus make available, the pertinent, scientific information on poultry nutrition which will enable poultrymen to feed chickens scientifically.

NUTRIENTS AND THEIR FUNCTIONS

The feed consumed by chickens normally contains the following seven classes of nutrients: (1) Proteins, (2) carbohydrates, (3) fats, (4) minerals, (5) vitamins, (6) extractives, and (7) water. Each class, except the last, includes at least several score and, in some cases, thousands of individual compounds.

Proteins

The proteins are compounds that always contain the chemical elements nitrogen, carbon, hydrogen, and oxygen. Most proteins contain sulphur and some contain phosphorus as well. Hemoglobin, an important protein of the blood, contains a small quantity of iron.

The most characteristic element in proteins is nitrogen; the quantity is not the same in all proteins but on the average it amounts to about 16 per cent. This fact is made use of by the chemist in determining the protein content of a feedstuff. The nitrogen content is first determined by a suitable method and is then multiplied by 6.25, since $100 \div 16 = 6.25$; the result is referred to as "crude protein". This procedure obviously does not give the true protein content because all feedstuffs contain variable, small quantities of nitrogen-containing compounds which are not proteins; nevertheless, it gives a valuable estimate.

Although there are many different proteins, all of them are composed of a relatively small number of comparatively simple compounds known as alpha-amino acids, or more simply as amino acids. As many as 25 different amino acids have been found in proteins and, of these, 22 are generally present; however, not all 22 are present in every protein.

The chicken is able to make in its own body some, but not all, of the amino acids; and most of those that it cannot make must be present in the feed or else normal nutrition is impossible. The amino acids which an animal requires for growth and reproduction, but is unable to make in its own body, are known as essential amino acids. According to nutrition studies conducted with rats the essential amino acids are (1) arginine, (2) histidine, (3) isoleucine, (4) leucine, (5) lysine, (6) methionine, (7) phenylalanine, (8) threonine, (9) tryptophane, and (10) valine. The available evidence indicates that these same amino acids are probably essential to the chicken as well as the rat.

In the practical feeding of animals two classes of proteins are commonly recognized: (1) plant proteins, those derived from plants; and (2) animal proteins, those derived from animals. Often reference is also made to the quality of a protein. A protein is said to be of good quality when it contains a sufficient quantity of those amino acids which the animal cannot make but which it requires for normal growth and reproduction. In

general, the plant proteins are inferior in quality to the animal proteins.

No two feedstuffs contain the same proteins and in general there are only a few that contain an adequate quantity of all the essential amino acids.

The great importance of the proteins in nutrition is indicated by their many functions in the animal body. They are indispensable constituents of the blood, muscles, organs, skin, tendons, bone, and feathers, in fact of all tissues of the animal body. They constitute about one-fifth of the live weight of the chicken and between one-eighth and one-seventh of the whole egg. A secondary function of protein is to serve as a source of energy. When an animal consumes more protein than it requires for growth, reproduction, or the repair of tissue, it may use the excess as a source of energy. Likewise, if feed is withheld from an animal, it is able for a limited period of time to use its own tissues, which are largely protein, as a source of energy.

Carbohydrates

One of the distinguishing characteristics of carbohydrates is that they are composed of carbon, hydrogen, and oxygen and that the last two elements are present in the same ratio as they are in water. This class of nutrients includes a number of physically unlike compounds such as cellulose, starch, dextrin, sugars, pectins, and certain gums. A second distinguishing characteristic is

that when they are digested they are all converted, in whole or in part, into simple sugars.

In the usual proximate chemical analysis of feedstuffs two physically different groups of carbohydrates are determined: (1) Crude fiber and (2) nitrogen-free extract. Crude fiber is the woody, fibrous portion and consists chiefly of cellulose and similar compounds. It is of relatively little importance as a nutrient to the chicken because it is not readily digested by this species. Nitrogen-free extract includes all of the carbohydrates that may be readily digested by animals, but, as chemically determined, it may include, as well, some carbohydrates which are not so readily digested but which may be brought into solution by dilute solutions of alkalies or acids.

The chief sources of carbohydrates are plant products; most animal products, with the exception of milk and whey, contain relatively small quantities.

The carbohydrates are the principal source of energy utilized by the animal body. They may be stored to a limited extent as glycogen in the liver and muscle tissues. When the quantity of carbohydrates consumed is greater than that which the animal can use to meet its immediate energy requirement, or store as glycogen, the excess may be converted into fat and be deposited in the body as a future source of energy.

Fats

Fats contain the same elements as carbohydrates, namely, carbon, hydrogen, and oxygen, but the ratio of hydrogen to oxygen is greater. Some fats also contain phosphorus. The common fats are chemical combinations of glycerin and fat acids, usually stearic, palmitic, and oleic acids.

The fats are important constituents of most of the tissues of the animal body. They are also found in fat deposits around the internal organs, between the muscles, and under the skin. In addition to performing important functions in the individual cells, they are carriers of the fat-soluble vitamins. Certain fat acids are essential for normal nutrition and, like the vitamins, are required in only very small quantities.

Another important function of the fats is to serve as a source of energy. For this purpose they are much more efficient than either the proteins or the carbohydrates, inasmuch as a given weight of fat supplies between 2.25 and 2.5 times as much energy as either protein or carbohydrate.

The animal may obtain its fat from three sources: the fat, the protein, and the carbohydrates of the feed. In other words, both carbohydrate and protein, after digestion and absorption, may be converted, in part, into fat.

Minerals

The term minerals, as it is now used in animal nutrition, refers simply to the inorganic elements.

When a feedstuff is burned, the ash that remains is a mixture of compounds of these inorganic elements.

The functions of the mineral or inorganic elements in the animal body are numerous. Compounds of these elements are found in varying quantities in all the tissues. In the absence of certain elements the various organs of the body are unable to perform their functions properly.

Calcium is the chief constituent of egg shells; calcium and phosphorus are characteristic constituents of the bones; iron is an indispensable constituent of the hemoglobin of the blood; iodine is an essential constituent of the secretion of the thyroid gland; compounds of sodium and potassium are necessary for maintaining the acid-base equilibrium of the body; and chlorine is an important constituent of the secretion of the proventriculus. Calcium also plays an important role in the clotting of blood; minute traces of copper are required by the animal to enable it to utilize iron in the formation of hemoglobin; and manganese is essential for reproduction and normal bone development in the chicken.

The chicken requires, for normal nutrition, sodium, potassium, calcium, magnesium, sulphur, phosphorus, chlorine, iron, iodine, manganese, copper, zinc, silicon, and possibly cobalt. Many other elements, among which are fluorine, bromine, aluminum, and boron, have been found in animal tissues, but it has not been definitely demonstrated

that they are required for the maintenance of life and reproduction.

Vitamins

The vitamins are a miscellaneous group of organic compounds that are characterized by the fact that only exceedingly small quantities are required by the animal organism. In spite of the small quantities required, they are absolutely essential for the maintenance of health, growth, and reproduction. They were formerly referred to as mysterious compounds of unknown composition, but during recent years the chemical composition and structure of most of them have been determined and several have been made in the chemical laboratory. The established vitamins are A, B_1, B_6, C, D, E, G, K, nicotinic acid, and pantothenic acid (chick antidermatosis factor); others have been postulated, and of these B_3, B_4, B_5, F, P, U, W, the anti-gizzard-erosion factor, and the Cornell growth and reproduction vitamin may be mentioned. However, this discussion deals chiefly with those of demonstrated importance in the practical feeding of chickens.

Vitamin A.—This is one of the so-called fat-soluble vitamins. In addition to vitamin A itself there are several of the carotinoid pigments, notably the carotenes, that can be converted into vitamin A in the animal body. Compounds that may be transformed by the animal into vitamins are known as vitamin precursors or provitamins.

Vitamin A is necessary for growth reproduction, hatchability, and the maintenance of health. It assists in maintaining the normal functions of epithelial and nerve tissues and is of value in prevention infections of the eye and respiratory tract. A deficiency of this vitamin or its precursors retards growth, decreases egg production and hatchability, and impairs general health.

Vitamin A is found chiefly in materials of animal origin. It is present in egg yolk and the abdominal fat of normal chickens. Cod-liver oil, when properly prepared, is a rich source of this vitamin. It is also found in other fish-liver and fish-body oils. Sardine oil contains about 13.5 per cent as much vitamin A as cod-liver oil.

The precursors of vitamin A occur chiefly in materials of plant origin but may be found in certain animal products such as butter and yellow animal fat. Green, leafy plants, such as kale, alfalfa and clover, and yellow roots and tubers, such as carrots and sweet potatoes, are generally good sources. When properly prepared, alfalfa meal and alfalfa leaf meal contain relatively large quantities of carotene which is the most common precursor of vitamin A. Yellow corn is a fair source of vitamin A precursors.

Vitamin A and its precursors are readily destroyed by oxidation but the latter not so readily as the former. They are also readily destroyed by heat. Because of vitamin A's susceptibility to oxidation, cod-liver oil should always be stored in closed, well-filled containers and should never be

mixed with the feed until a short time before it is to be used. Alfalfa, corn, and other plant products tend to lose as much as 50 per cent, or even more, of their vitamin A potency if stored as long as a year.

Vitamin B_1.—This vitamin is one of the water-soluble group. It is necessary for growth, the maintenance of appetite and a normal condition of the intestinal tract, and for the prevention of the nerve disorder known as polyneuritis. It plays an important part in the utilization of carbohydrates by the animal body.

Vitamin B_1 is widely distributed in nature and is found in both plant and animal materials. Yeast, the germs of seeds, and the seeds of legumes are among the best sources. In general, the seeds are all very good sources. The green vegetables are also fairly good sources. In typical diets for chickens the chief sources of this vitamin are the cereal grains and their by-products.

Vitamin B_1 is readily destroyed by heat, especially in the presence of alkalies. Under ordinary conditions feedstuffs may be stored for a long time without there being any serious loss of this vitamin.

Vitamin B_6.—This is another of the water-soluble vitamins. It appears to be necessary for the normal growth of chickens and for the prevention of a type of nerve disorder. In general, feedstuffs that are sources of vitamin B_1 are also sources of B_6. It is comparatively stable and is widely dis-

tributed in both plant and animal products. Among the good sources of vitamin B_6 are yeast, liver, corn, rice polishings, rice bran, wheat germ and molasses. The cereal grains and their by-products are all fairly good sources. Practical diets for chickens are not likely to be deficient in this vitamin, because it is widely distributed in those feedstuffs that are commonly fed to chickens.

Vitamin C.—This is also one of the water-soluble vitamins. The chicken is normally able to make its own vitamin C and for that reason it is generally believed that the diet of this species need not contain any. It may be pointed out, however, that there are certain conditions (pullorum disease, for example) in which vitamin C may be destroyed as rapidly as it is formed. This strongly suggests that it is advisable to include some alfalfa leaf meal or fresh green feed in the diets of chickens, especially during outbreaks of pullorum disease.

Vitamin D.—This vitamin belongs to the class known as the fat-soluble vitamins. It occurs in several forms, some of which are more effective than others in the chicken. It is unique among the vitamins in that it may be produced in the skin of animals through the action of ultraviolet rays which may be obtained from the sun or from artificial sources, such as the carbon arc or the quartz-enclosed mercury-vapor lamp.

Vitamin D is necessary for normal bone growth, egg production, and hatchability. A deficiency of

vitamin D produces rickets in growing chicks, decreases the egg production of laying chickens, and lowers the hatchability of eggs. On the other hand if a chicken gets too much vitamin D, 5 or 6 times the quantity normally required, egg production and hatchability of the eggs will decrease; there may also be a deposition of calcium in various tissues of the body other than the bones.

Vitamin D is not widely distributed in nature. Cod-liver oil, sardine oil and some other fish oils are the richest natural sources. Egg yolk is a fair source. The ordinary feedstuffs contain little or none. However, vitamin D activity may be conferred on certain oils and feedstuffs by irradiation with ultraviolet rays.

Vitamin D is very stable under ordinary conditions; however, there is some destruction of this vitamin in feeds containing cod-liver oil or other similar sources when the feeds are stored for a long time.

Inasmuch as some of the forms of vitamin D are more effective than others in the chicken, all sources of this vitamin intended for use in the feeding of poultry should be purchased on the basis of their content of A. O. A. C. chick units of vitamin D.

Vitamin E.—This is another of the so-called fat-soluble vitamins. It is necessary for reproduction and the hatchability of eggs. This vitamin is widely distributed in nature. Green leaves and the germs of seeds are the best known sources; it is also found in certain fresh fats. Vitamin E is

quite stable under ordinary conditions. It may be subjected to fairly high temperatures and air may even be blown through oils containing it at temperatures below 208° F. without appreciable destruction taking place; but it is very readily and quickly destroyed by rancid fats. For this reason rancid feeds—even when the rancidity is slight—should never be used.

Vitamin G, or riboflavin.—The several biologically active flavins, which are collectively known as riboflavin, are referred to as vitamin G.

Vitamin G is necessary for growth and for the hatchability of eggs. A deficiency of this vitamin increases embryonic mortality and very markedly retards the growth of young chickens.

The richest sources are liver and other glandular tissues, yeast, dried whey, and dried skim milk. Alfalfa, if properly harvested and cured, is a very good source; in general, alfalfa leaf meals contain more than the straight alfalfa meals. Fish meals, meat meals, and wheat germ are fair sources. The cereal grains contain relatively little.

Vitamin G is not rapidly destroyed by heat. In relatively pure form, especially in solution, it is changed into inactive compounds through the action of strong light. The vitamin G in natural feedstuffs appears to be quite stable under ordinary conditions of storage.

Vitamin K.—This vitamin is also known as the antihemorrhagic factor. It has been found in such diverse materials as hog-liver fat, hempseed meal,

tomatoes, kale, and dried alfalfa. When the diet is deficient in this factor, the time required for the blood to clot is greatly increased and hemorrhages may occur in the various tissues. The indications are that the ordinary poultry diets are not likely to be deficient in this factor.

Nicotinic acid.—This vitamin, or vitamin-like factor, is required for the normal nutrition of several species, including man, the dog, the pig, and the pigeon, but it has not been demonstrated as yet that it is required for the normal nutrition of the chicken. According to the available evidence, if this vitamin is required by the chicken, it can be synthesized by this species or else the quantity required is exceedingly small.

Good sources of this vitamin are liver, yeast, rice polishings, dried milk, and green plant materials. On the other hand, corn and molasses contain virtually none.

Panothenic acid, or the chick antidermatosis factor.—This factor has been referred to as filtrate factor 2, or simply as the filtrate factor. It is present in grain, grain products, and various other feedstuffs. One of the richest but rather variable sources is cane molasses; other sources, in the order of their relative content are peanut meal, dried whey, dried buttermilk, dried skim milk, dehydrated alfalfa leaf meal, dried skim milk, alfalfa meal, wheat bran, rice bran, soybean meal, wheat middlings and cereal grains. Typical diets for chickens are not likely to be seriously deficient in this factor.

Anti-gizzard-erosion factor.—This factor, or factors—for there is evidence that there is more than one factor—is not designated by a letter as are most of the vitamins. It has been found in a number of materials among which are wheat bran, alfalfa products, lung tissue, kale, pork liver and kidney, wheat middlings, and oats. There is evidence that ordinary diets may be partially deficient in this factor.

Extractives

The class of nutrients known as extractives includes a number of different compounds such as non-protein nitrogen compounds and organic acids. In brief, it includes most organic compounds not properly classified as proteins, carbohydrates, fats, and vitamins. However, it originally included the latter until their special nutritive properties were learned and they were designated as a special class of nutrients. As a class, the extractives appear to be of little practical importance in nutrition.

Water

The importance of water as a nutrient cannot be too strongly stressed. It is an essential constituent of all animal tissues. It is absolutely necessary for the processes of digestion, it carries materials from one part of the animal body to another, and it serves an important function in the regulation of body temperature. An animal de-

prived of water dies more quickly than one deprived of all the other nutrients. Its importance is further demonstrated by the fact that it accounts for about 60 per cent of the live weight of the chicken and about 65 per cent of the weight of the egg.

DIGESTION

Before the feed consumed by a chicken can be absorbed and utilized for growth, maintenance, or egg production it first must be digested. Digestion is essentially a process wherein the proteins, fats, and carbohydrates combine with water and are then split into simpler compounds which may be absorbed. This process takes place through the action of substances known as enzymes. There are small quantities of enzymes in most feedstuffs but by far the greater part of those used in digesting the feed are supplied by the chicken's body.

After the feed has been picked up and swallowed, it is passed on to the crop by the muscular action of the gullet. If there is no feed in the gizzard, a small part of that which first reaches the crop is passed on to the proventriculus and then, after a short pause, to the gizzard. A series of muscular contractions and relaxations takes place in the gizzard as soon as the food reaches it. These are continued until the feed is reduced to a finely ground, pasty mass, when it is then passed on to the small intestine. After entering the small intestine, the mass of finely ground feed is slowly pushed toward the other end by a series of relaxations and contractions of the intestinal muscles. While being passed from the one end of the small intestine to the other the feed mass is thoroughly

broken up and remixed by a series of irregular and independent muscular contractions. After being pushed through the small intestine the feed mass enters the large intestine and a part is slowly drawn into the ceca and the remainder passed on. At intervals of about 8 hours the ceca expel their contents and slowly fill again. All the while the large intestine continues to pass its contents on to the cloaca from which, after most of the liquid portion has been absorbed, they are passed on out of the body.

Each time after the gizzard empties itself, another portion of the feed is passed on from the crop and this continues until the crop is emptied. The length of time required for a complete emptying of the crop varies from 1 or 2 hours to as long as 16 or 17 hours, depending on the nature of the feed and the quantity consumed.

Some digestion takes place in the crop due to the combined effect of the moisture and warmth supplied by the chicken's body and the enzymes originally present in the feed. The rate of digestion promptly increases as soon as the feed reaches the gizzard but by far the greater part of the digestion takes place in the small intestine after the feed has been mixed with the gastric juice of the proventriculus and ground by the gizzard. The digestion in the small intestine is brought about through the action of the gastric juice, the bile, and the enzymes of the pancreatic and intestinal secretions. Bile and the pancreatic secretion are added to the food mass after it has traversed the

duodenal loop of the small intestine, and the intestinal secretion is added as the feed continues on its course.

Digestive changes are extremely rapid in the chicken; in as little as 1½ to 2 hours after the feed leaves the crop, an individual portion may be digested and the indigestible residue voided. However, for the complete digestion of a full meal, as little as 10 hours or as much as 18 hours may be required; the average time is close to 14 hours, but may be appreciably less when nothing but a wet mash is fed.

In the process of digestion the proteins are split into simple combinations of amino acids as well as into the amino acids themselves, the carbohydrates into simple sugars, and the fats into glycerol and fat acids. Most of these products of digestion are then absorbed and the glycerol and fat acids recombined to form fats. The recombined fats and the other absorbed products are then carried by the blood and lymph to the various parts of the body for the building of new tissues and the production of heat and muscular activity. Excess carbohydrates and fats are either burned or stored as fat for future use. The amino acids that cannot be used are promptly deaminated, so that the nitrogen-containing portion can be converted into compounds that are readily eliminated, and the other portion is used as a source of energy or is converted into fat.

Grit and the Gizzard

The chief, and perhaps only, function of the gizzard is to grind feed. The truth of this statement was convincingly demonstrated by some experiments conducted at the Beltsville Research Center, Beltsville, Md., in which chickens lived for as long as 4 years after their gizzards had been removed surgically. It was found, however, that the chickens without gizzards did not digest so much of their feed, unless it was finely ground, as did other chickens from which the gizzards had not been removed.

In the same series of experiments the effect of grit on the digestibility of feed was studied. It was found that although chickens can digest whole grain without the aid of grit, the percentage digested is somewhat increased, if there is some grit in the gizzard. Furthermore, experiments on the economy of feed utilization have indicated that the energy required for grinding feed by the gizzard is less when some grit is present than when it is totally absent. In spite of the fact that grit is not essential to the chicken, it must be conceded that it can play an important part in the digestion of feed by this species. Additional evidence of the importance of grit in the feeding of chickens is supplied by the fact that if young growing chickens are fed a finely ground feed that contains little or no fiber and no grit, an abnormal condition of the gizzard lining develops.

In view of these experimental observations, it is clear that it is a worth-while practice to supply

grit to chickens so reared and kept that they do not have access to the soil. However, it is highly important that careful consideration be given to the kind of grit that is supplied. Although coarsely crushed oyster shell and limestone may serve as grit, their use is not to be recommended because of the danger of the chickens' consuming too much calcium in their effort to get enough grinding material. Of course, there is no objection to the use of finely ground oyster shell or limestone as a source of calcium in the feed of chickens, but the quantity should be regulated and this is not possible if calcium-bearing grits are used. In choosing a grit, care should be taken to select one that is insoluble and nonfriable. Ordinarily, the best available material for use as grit is river gravel or native pebbles of suitable size.

Bulk and Fiber

Excessively bulky feeds and those of unusually high fiber content are not well utilized; neither are the very concentrated feeds. Some of the more bulky feedstuffs in the ordinary feed mixtures given to chickens are: Bran, distillers' and brewers' dried grains, alfalfa meal, ground oats, wheat middlings, linseed meal, oats, barley, and hominy feed. A few of the less bulky feedstuffs are: Polished rice, wheat, corn, peas, millet, dried skim milk, dried buttermilk, fish meal, and meat scrap.

When the bulkiness of feedstuffs is compared with their fiber content, it is found that there is no marked relationship between the two. For exam-

ple, although wheat bran is one of the bulkiest of feedstuffs fed to chickens, it contains less than a third as much fiber as does sunflower seed, which is one of the less bulky ones.

There is some evidence that the presence of a small quantity of indigestible and somewhat bulky material in the intestines facilitates both the digestion and absorption of the digestible portion. Ordinarily, the crude fiber in the feed serves as a source of such material because the chicken does not digest crude fiber readily. It is not possible to state just how much crude fiber a diet should contain because the physical properties of crude fiber from different sources vary greatly. Ordinarily, 3 to 5 per cent is enough, although in some cases the diet may contain as much as 10 per cent without having any markedly detrimental effect.

UTILIZATION OF FEED

Not all the feed consumed by chickens is used for the building of new tissues or the production of eggs; some is used as a source of heat, some for muscular activity, and some for the maintenance of all the various tissues and functions of the body.

Growth

The quantity of feed consumed by an animal determines its rate of growth and a young actively growing animal uses its feed more efficiently than an older one. The relationship between live weight and feed consumption in the growing animal follows a rather simple, definite law, known as the law of diminishing returns. The way in which this law operates is shown in figure 1, in which the average live weight of a group of crossbred males (the offspring resulting from mating Barred Plymouth Rock females with Rhode Island Red males) is plotted against cumulative feed consumption.

The figures directly beneath the curve in figure 1 are the pounds of gain in live weight resulting from the consumption of each successive five pounds of feed. An examination of this figure readily shows that the second 5 pounds of feed produced only 81.1 per cent as much gain as did the first 5 pounds, that the third 5 pounds produced only 81.1 per cent as much gain as did the

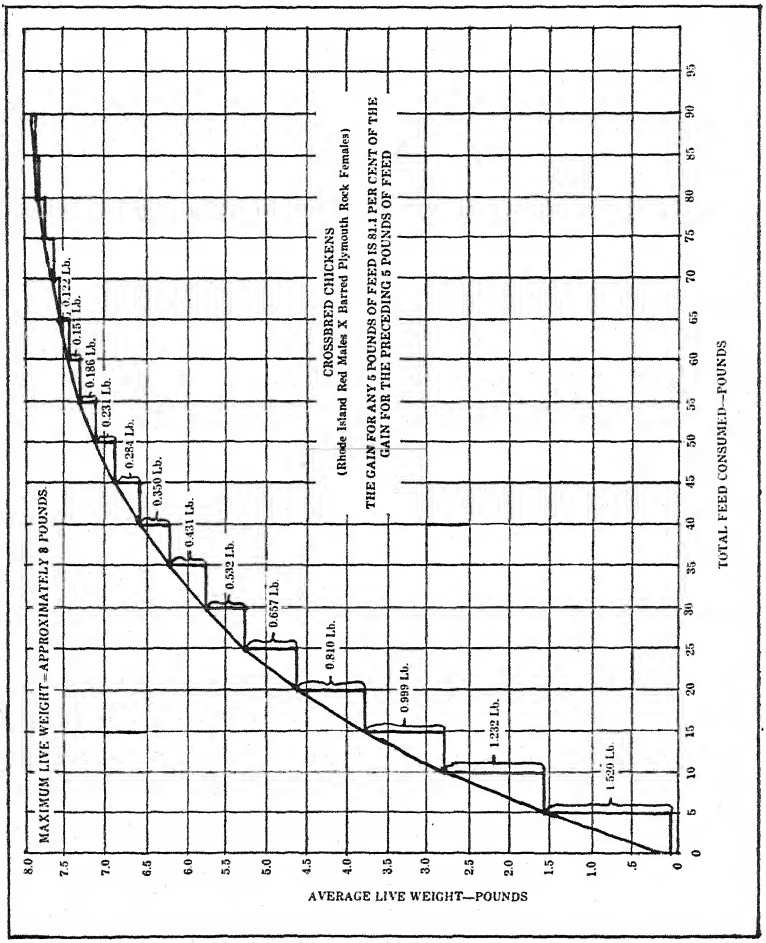

Fig. 1. The relationship between live weight and feed consumption in crossbred chickens (the offspring resulting from mating Barred Plymouth Rock females with Rhode Island Red males).

second 5 pounds, and so on. As a result of the operation of the law of diminishing returns, it will be seen that the twelfth 5 pounds of feed produced only about one-tenth as much gain as did the first 5 pounds. If, in figure 1, the gains were shown for each pound of feed instead of each 5 pounds, it would be found that the second pound produced only 95.9 per cent as much gain as did the first pound, the third pound only 95.9 per cent as much gain as the second pound, and so on.

The reason that successive equal weights of feed do not produce equal gains is briefly as follows: The daily feed consumption of a growing chicken increases as the live weight increases but the former not so rapidly as the latter. Furthermore, as the chicken becomes heavier, more and more feed is required for maintenance and so an increasingly smaller percentage is left for growth. The net result is that the gain resulting from a given weight of feed becomes progressively smaller.

Under ordinary conditions male chickens are somewhat more efficient in their utilization of feed for growth than are the females of the same breed. It has been found, also, that chickens of some breeds utilize their feed more efficiently than others to reach a given live weight; the same is true of different kinds of poultry. This is clearly shown in table 1, in which is given the quantity of feed required by three different kinds of poultry—including chickens of three breeds—to reach different live weights from 0.5 to 5 pounds. However,

it should be noted that the data in table 1 cannot be used for making exact comparisons of the efficiencies of the different kinds of poultry in utilizing feed for growth, because no two of the diets that were fed were the same. Nevertheless, diets suitable for each kind of poultry were fed, and hence these data indicate in a general way the relative abilities of chickens, turkeys, and ducks to utilize feed for growth.

The relationship between live weight and feed consumption is shown in another way in table 2, in

Table 1. The feed required to obtain certain selected average live weights with different kinds of poultry.

Average live weight	Kind of poultry and quantity of feed required per bird					
	White Leghorns (males and females)[1]	White Leghorns (males)	Crossbreds[2] (males)	Rhode Island Reds (males)	Turkeys[3] (males)	White Pekin ducks (males[1] and females)
Pounds	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds
0.5	1.38	1.30	1.29	1.12	0.95	0.83
1.0	3.18	3.00	2.91	2.53	2.20	2.01
1.5	5.27	4.94	4.65	4.05	3.49	3.28
2.0	7.75	7.21	6.52	5.69	4.83	4.66
2.5	10.80	9.93	8.56	7.49	6.21	6.17
3.0	14.75	13.34	10.78	9.46	7.65	7.83
3.5	20.39	17.91	13.24	11.66	9.15	9.68
4.0	.....	24.84	15.97	14.13	10.70	11.77
4.5	.....	39.75	19.07	16.95	12.32	14.17
5.0	.....	.....	22.62	20.25	14.02	16.99

[1] For a group containing approximately the same number of birds of each sex.
[2] The male offspring resulting from mating Barred Plymouth Rock females with Rhode Island Red males.
[3] Several different breeds from parent stock which had been selected for small size.

which are given the live weights of different kinds of poultry when first fed and their live weights after they have consumed from 1 to 15 pounds of feed. The gain in live weight for each pound of feed is also given. This table readily shows that in mixed White Leghorn males and females the gain produced by any given pound of feed after the first is about 92.8 per cent as great as that produced by the preceding pound of feed; in White Leghorn males it is about 92.9 per cent as great; in the crossbred males it is about 95.9 per cent as great; and in the Rhode Island Red males, the turkey males, and the mixed White Pekin males and females, it is about 95.1, 97.4 and 94.0 per cent, respectively, as great.

The efficiency of feed utilization for growth varies not only with the breed and the kind of poultry but with the type of diet consumed and the temperature of the environment as well. Nevertheless, the information contained in tables 1 and 2, and that supplied by figure 1, is of value to the poultryman who wishes to know how much feed ordinarily will be required to obtain a given average increase in live weight.

Table 2. The relation between live weight and feed consumption of different kinds of poultry.

Feed consumed per bird	White Leghorns[1] (males and females)		White Leghorns (males)		Crossbreds[2] (males)		Rhode Island Reds (males)		Turkeys[3] (males)		White Pekin ducks[1] (males and females)	
	Average live weight	Gain in live weight	Average live weight	Gain in live weight	Average live weight	Gain in live weight	Average live weight	Gain in live weight	Average live weight	Gain in live weight	Average live weight	Gain in live weight
Pounds	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds
0	0.072	0.000	0.072	0.000	0.077	0.000	0.077	0.000	0.111	0.000	0.126	0.000
1	.387	.315	.404	.332	.407	.330	.456	.379	.522	.411	.574	.448
2	.681	.294	.713	.309	.724	.317	.817	.361	.923	.401	.996	.422
3	.952	.271	1.000	.287	1.027	.303	1.159	.342	1.313	.390	1.393	.397
4	1.205	.253	1.266	.266	1.318	.291	1.485	.326	1.693	.380	1.765	.372
5	1.439	.234	1.514	.248	1.597	.279	1.795	.310	2.063	.370	2.116	.351
6	1.656	.217	1.744	.230	1.865	.268	2.089	.294	2.424	.361	2.446	.330
7	1.858	.202	1.957	.213	2.121	.256	2.369	.280	2.776	.352	2.756	.310
8	2.045	.187	2.155	.198	2.367	.246	2.634	.265	3.118	.342	3.048	.292
9	2.219	.174	2.340	.185	2.603	.236	2.887	.253	3.452	.334	3.322	.274
10	2.380	.161	2.511	.171	2.829	.226	3.128	.241	3.777	.325	3.580	.258
11	2.529	.149	2.670	.159	3.046	.217	3.356	.228	4.094	.317	3.822	.242
12	2.668	.139	2.818	.148	3.254	.208	3.573	.217	4.402	.308	4.050	.228
13	2.797	.129	2.955	.137	3.454	.200	3.780	.207	4.703	.301	4.265	.215
14	2.916	.119	3.083	.128	3.645	.191	3.976	.196	4.995	.292	4.467	.202
15	3.027	.111	3.201	.118	3.829	.184	4.162	.186	5.281	.286	4.656	.189

[1] For a group containing approximately the same number of birds of each sex.
[2] The male offspring resulting from mating Barred Plymouth Rock females with Rhode Island Red males
[3] Several different breeds from parent stock which had been selected for small size.

Egg Production

A part of the feed consumed by a pullet is used for growth and the remainder for maintenance and egg production. In the yearling hen, the feed is used chiefly for the last two purposes but some is used for regaining the weight lost during the molt which usually takes place during the last few months of the pullet year.

Studies of the feed requirements of laying chickens have shown that after feed enough has been consumed to take care of the growth and maintenance requirements, approximately 0.09 pounds of additional feed must be consumed for each egg that is laid. Thus it is readily apparent that of two chickens of equal live weight, the one that lays the larger number of eggs requires the more feed. If one of two such chickens lays only 60 eggs during a year the other lays 160 eggs, the latter will require nearly 9 pounds more feed than the former.

Figure 2 shows how the average quantity of feed consumed per bird, per year, depends on the average percentage egg production. Curves are presented for Rhode Island Red pullets and yearling hens and for White Leghorn pullets and yearling hens. The quantities of feed indicated for a given percentage egg production are only approximate because they depend to a considerable extent on the average live weight of the chickens. In general, the heavier strains of both breeds will require somewhat more feed than the lighter strains.

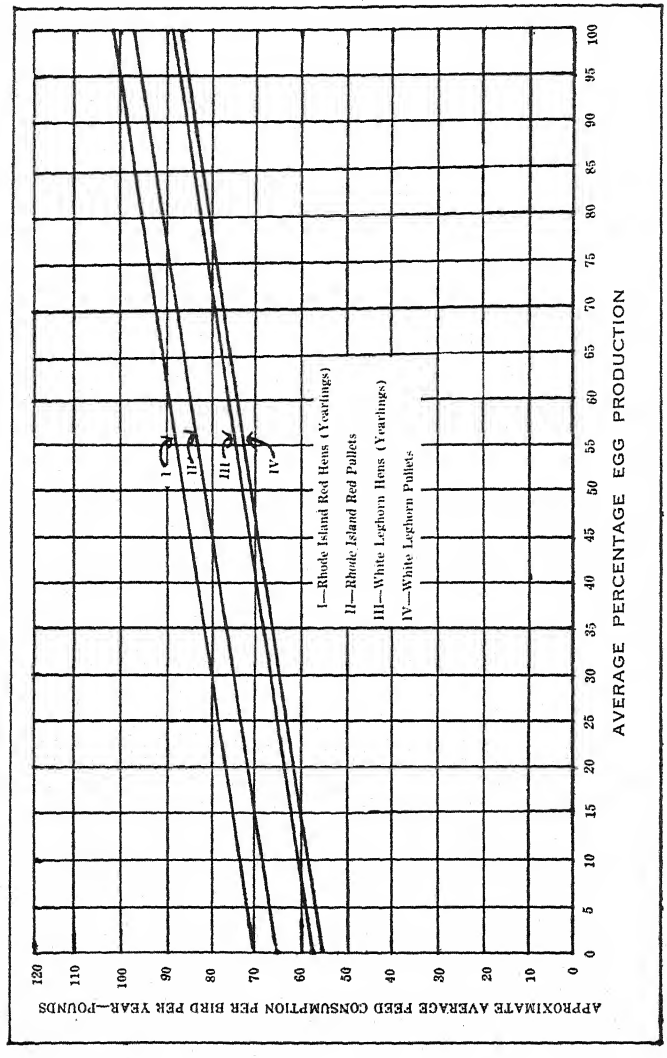

Fig. 2. The relationship between feed consumption and egg production of yearlings and pullets of two breeds.

NUTRITIVE REQUIREMENTS OF CHICKENS

In the efficient feeding of all classes of chickens the necessary nutrients must be fed in adequate quantities. The diet must supply enough protein, carbohydrate, fat, minerals, vitamins, and water to meet all the requirements of growth, maintenance, and egg production. If considerably more protein, fat, and vitamins are supplied than required, the chickens may be well but not economically nourished, because these are the three most expensive nutrients. In other words it is not economical to force chickens to use protein and fat as sources of energy when the cheaper carbohydrates will serve the same purpose just as well, or even better; nor is it economical to supply the vitamins in gross excess of the chicken's requirements. Likewise, it is not economical to supply too small quantities of minerals and vitamins and thus cause the chickens to use the protein in their feed less efficiently.

On the other hand, it is more economical to feed somewhat more protein and vitamins than may be required under ordinary conditions than it is to feed too little. This is also true of the mineral elements; but in attempting to supply them in adequate quantities there is likely to be a tendency to use too much because they are relatively cheap.

Any great excess of the mineral elements in the diet should be carefully avoided.

It is well known that the composition of most feedstuffs varies, and in some instances varies considerably. For example, some lots of corn may contain as little as 8 per cent of protein and others as much as 11 per cent; some lots of dried buttermilk may contain as little as 0.5 per cent of fat and others as much as 8 per cent; some lots of middlings may contain several per cent more of crude fiber than others and considerably less protein; and the vitamin A potency of some lots of yellow corn or alfalfa leaf meal may be only 25 to 50 per cent as much as that of other lots of these same feedstuffs.

Ordinarily, a poultryman does not have the facilities necessary for making chemical analyses and vitamin assays of the feedstuffs he uses. Furthermore, such analyses and assays involve too great an expense for most poultrymen to incur. However, if suitable allowances are made for the natural variability of feedstuffs, it is possible to use tables that give the average chemical composition and vitamin content. Such tables are given at the end of this book.

In listing there the nutritive requirements of chickens allowance is made for the fact that many of the nutrition experiments, from which the data were obtained, were designed to determine the minimum rather than the optimum requirements. Allowance is also made for the fact that the composition and vitamin content of feedstuffs may

vary considerably. For example, most of the studies of the vitamin D requirements of growing chickens have shown that the minimum quantity required is between 60 and 90 A. O. A. C. chick units per pound of feed. However, there are indications that with some diets and under some conditions the optimum quantity of vitamin D is close to 180 A. O. A. C. chick units per pound of feed. Accordingly, the vitamin D requirement of growing chicks is given as 180 A. O. A. C. chick units per pound of feed.

The usual primary object in keeping chickens is to make as much profit as possible. Inasmuch as rapidly growing chickens make more economical gains than those that grow slowly, and high egg production cannot long be maintained on a limited diet, it has become a rather general practice to feed both growing and laying stock as much feed as they will consume. Systems of rationing, that is, systems of supplying only just enough feed to meet the minimum nutritive requirements of growth or of some predetermined rate of egg production generally have not proved to be popular or profitable. Accordingly, in stating the nutritive requirements of the several classes of chickens, particular attention is given to the problem of supplying protein, minerals, and vitamins in quantities that will sustain a rapid rate of growth or of egg production. No attempt is made to control directly the carbohydrate intake and only in the case of chickens being finished for market is the fat intake given any special consideration.

Growing Chickens

Nature provides a concentrated supply of nutrients for the newly hatched chick within its own body. The unabsorbed yolk constitutes this supply. It is sufficient to maintain the chick for several days, but experience has shown that the best results are obtained if both water and feed are supplied when the chick is about one day old.

Protein.—Studies of the effect of the level of protein intake on growth have shown that the physiologically optimum percentage of protein in the diet of the growing chick is approximately 21 per cent, when the protein is of reasonably good quality. This level gives the best results in growing chicks of all live weights from hatching until body growth is nearly complete. It has been observed, however, that after the chicks are about 12 to 16 weeks old the rate of growth may be more rapid on a somewhat lower level of protein intake. Nevertheless, the utilization of feed for growth is more efficient in actively growing chicks of the same weight, regardless of age, when the diet contains about 21 per cent of protein than when it contains appreciably less.

The apparent disagreement between the last two statements may be explained as follows: Chicks ordinarily grow more rapidly on a diet that contains 21 per cent of protein than on one that contains 18 per cent when the protein in both diets is of the same quality. On any diet of fixed protein content the efficiency of feed utilization decreases as the live weight increases. Hence, if two equal

lots of chicks from the same hatch are fed diets that contain 21 and 18 per cent of protein, respectively, the lot of chicks receiving the larger percentage of protein will grow more rapidly than the other lot and, as a consequence, the efficiency of feed utilization of this lot will decrease more rapidly than that of the other lot. By the time both lots are about 16 weeks old the rate of growth of the second lot may be definitely greater than that of the first lot. However, as the live weight of the second lot increases, the efficiency of feed utilization decreases at such a rate that for any given live weight less than the mature weight it is less than that of the first lot.

Although a diet containing about 21 per cent of protein is more efficiently utilized than one containing about 18 per cent, the latter diet may be more economical if its cost is sufficiently less than that of the former. In any case, it is ordinarily best to start with a well-balanced diet containing about 20 to 22 per cent of protein and then decrease the protein content gradually after the chicks are about 10 to 12 weeks old, if the cost of the resulting gain is thereby reduced enough to warrant the change. Frequently the cost of the resulting gain is decreased enough to warrant the gradual lowering of the protein content of the diet until it is as low as 15 or 16 per cent by the time the pullets are ready to be placed in laying quarters.

The data in table 3 may be used as an approximate guide in deciding which of two diets of dif-

ferent protein content will be the more economical to use. However, it is obvious that the comparison will not be valid, unless both diets contain protein of essentially equal quality, or biological value. According to these data, if one diet contains 21 per cent of protein and sells for 40 dollars per ton and another diet contains 18 per cent of protein and sells for 38 dollars per ton, the second one will be the more economical if both contain protein of

Table 3. Effect in the male chicken of the level of protein intake on the relative efficiency of the utilization of feed for growth, the relative maximum live weight attained, the relative quantity of feed required for attaining the maximum live weight, and on the relative length of time required to attain the maximum live weight.

Level of protein in take as per cent of the total feed consumed	Relative average efficiency of the utilization of feed for growth	Relative maximum live weight[1] attained	Relative quantity of feed required for attaining the maximum live weight[1]	Relative length of time required to attain the maximum live weight[1]
Per cent	Per cent	Per cent	Per cent	Per cent
13	67.7	97.6	144.1	119.9
14	80.6	97.9	121.3	111.7
15	87.3	98.2	112.5	107.8
16	91.5	98.6	107.7	104.6
17	94.6	98.9	104.6	102.6
18	97.2	99.2	102.1	101.5
19	98.7	99.5	100.7	101.0
20	99.7	99.8	100.1	100.5
21	100.0	100.0	100.0	100.0
22	97.9	100.2	102.3	99.7
23	94.3	100.4	106.4	99.5
24	90.2	100.5	111.4	99.4
25	85.6	100.6	117.5	99.2

[1] This refers to the maximum live weight that is attained when the birds are fully grown.

equal quality. This follows from the fact that the second diet costs only 95 per cent as much as the first but is 97.2 per cent as efficient. However, if the second diet sells for 39 dollars per ton, it is slightly less economical than the first because it costs 97.5 per cent as much and is only 97.2 per cent as efficient.

Minerals.—Analyses of the entire carcasses of growing chicks indicate that for each part by weight of phosphorus retained from the feed, about 1.5 parts of calcium are also retained. That is to say, the retention ratio of calcium and phosphorus is about 1.5:1. Analyses of both the feed consumed and of the carcass show that the minimum calcium requirement of the growing chick, when expressed as per cent of the diet, decreases with age. Such analyses also indicate that the minimum calcium and phosphorus requirements of very young chicks are met by a diet that contains about 0.75 and 0.55 per cent of these elements, respectively. The optimum levels of calcium and phosphorus intake are undoubtedly appreciably greater. Inasmuch as most practical diets capable of supporting a rapid rate of growth contain 0.7 per cent or more of phosphorus, it usually is unnecessary to include a special source of phosphorus. However, when the phosphorus level is less than 0.7 per cent, it should be increased by adding a small quantity of steamed bone meal, preferably the kind known as special steamed bone meal.

Observations on the excretion of excess calcium and phosphorus suggest that from a physiological

standpoint these two elements are most easily eliminated in a ratio of about 1.3:1. However, they may be readily excreted in much higher ratios. These considerations and the results of numerous experiments lead to the conclusion that the ratio of calcium to phosphorus in the diet of growing chickens may vary from about 1.3:1 to about 2:1. In order that the diet may contain enough calcium, it is usually necessary to add a small quantity of finely ground oyster shell or high-calcium limestone. Excesses of both calcium and phosphorus should be avoided.

All classes of chickens require a small quantity of sodium chloride (common salt) in their diet. The quantity to include in the diet depends to a certain extent on the other ingredients. If the diet contains very much meat scrap, meat-and-bone scrap, or fish meal, about 0.5 to 0.75 per cent of salt will be enough but otherwise 0.75 to 1 per cent will be required.

Recent studies of the mineral requirements of chickens have shown that perosis, or hock diseases, is caused by a deficiency of the element, manganese. If, however, a mixture of 100 parts by weight of common salt and 1.7 parts of anhydrous manganous sulphate is used in place of the common salt in the diet of both the laying hens and the growing chicks, perosis will be largely if not entirely prevented.

Vitamins.—In compounding diets for growing chickens special attention should be given to the matter of supplying adequate quantities of vita-

mins A, D, and G. Typical diets for growing chicks will normally contain fully adequate quantities of vitamins B_1 and E. A satisfactory level of vitaman A intake for growing chicks is approximately 1,450 International Units per pound of feed. One-half as much (725 International Units) will maintain life and support reasonably good growth but this quantity per pound of feed is to be considered as the minimum level rather than as a practical level.

As previously stated, the optimum level of vitamin D intake of growing chicks is close to 180 A. O. A. C. chick units per pound of feed. The relatively scanty information about the chick's requirement of vitamin G and pantothenic acid indicates that each pound of feed should supply about 1,670 micograms of the former and 0.9 modified Jukes-Lepkovsky unit[1] of the latter. The growing chick's vitamin B_1 requirement is tentatively set at 180 International Units per pound of feed. With the information available it is not possible to state quantitatively the chick's vitamin E requirements.

Laying and Breeding Stock

The nutritive requirements of laying chickens are qualitatively the same as those of growing chicks; however, they are quantitatively different. As indicated in figure 2, the greater the egg production the greater is the quantity of feed required.

[1]See footnote 4 of table 11 or footnote 5 of table 14.

Protein.—Although the protein requirement of laying chickens has been studied by many investigators, the optimum percentage of protein in the diet has not been determined accurately from the standpoints of physiological efficiency and financial economy. Excellent egg production—200 eggs or more per year—has been obtained on diets containing as little as 13 per cent of protein. However, a number of experiments have shown that as the protein content of the diet is increased from 13 to 18 or even 20 per cent there is a tendency for the egg production to increase. Experience has shown that both live weight and good egg production can be maintained on diets containing 15 per cent of protein. Nevertheless, a diet containing 16 to 17 per cent can be relied on under a greater variety of conditions than can one containing only 15 per cent. This is especially true in the case of pullets during their first four months of egg laying, because during this period protein is required for both growth and egg production. During the next four to six months 15 to 16 per cent of protein is adequate but as soon as the birds begin to molt, some advantage is gained by feeding a diet containing about 17 per cent of protein. After the molt is completed, 16 per cent of protein is again adequate.

Minerals.—The calcium requirement of laying chickens is very high because of the relatively large quantity of this element used in making egg shells. However, a large excess of calcium in the diet adversely affects the hatchability of the eggs.

Comparatively little is known of the phosphorus requirement of laying chickens but there is some evidence that a high level of phosphorus intake increases the calcium requirement. For this reason it is desirable to control both the calcium and phosphorus intake.

Both experimental results and theoretical considerations indicate that the proper percentage of calcium in the diet depends on (1) the number of eggs laid per bird, (2) the quantity of feed consumed, and (3) the phosphorus content of the diet. When the average egg production and average feed consumption of a flock are known or can be predicted, the following formula may be used for computing the proper calcium content of the diet:

$$Ca = 1.292\ P + \frac{0.41E}{F}$$

In this formula,

Ca=the proper percentage of calcium in the diet;
P=the per cent of phosphorus in the diet;
E=the average number of eggs laid per bird per year, and
F=the number of pounds of feed consumed per bird per year.

The following example illustrates the application of this formula. A poultryman has a flock of White Leghorn pullets which, according to the performance of the parent stock, should produce about 200 eggs per bird per year. The feed con-

sumption of the parent stock during the pullet year was 72 pounds of feed per bird. An analysis of the feed shows that it contains 1.1 per cent of phosphorus. On substituting these numerical data in the formula, the proper calcium content is found to be:

$$Ca=(1.292\times 1.1)+\frac{0.41\times 200}{72}=1.4212+1.1389=2.5601$$

Thus, it is found that the feed should contain about 2.56 per cent of calcium.

Inasmuch as the laying chicken can readily adapt her physiological processes to diets containing somewhat more calcium and phosphorus than she needs, it is possible to set up standards for the calcium and phosphorus content of the diet that will be applicable under all ordinary conditions.

Table 4. The corresponding approximate percentages of phosphorus and calcium for all-mash diets and for laying mashes with which grain is to be fed.

All-mash diets		Laying mashes (with which grain is to be fed)	
Phosphorus content	Calcium content	Phosphorus content	Calcium content
Per cent	Per cent	Per cent	Per cent
0.6	1.9	0.8	3.7
0.7	2.0	0.9	3.8
0.8	2.1	1.0	3.9
0.9	2.3	1.1	4.1
1.0	2.4	1.2	4.2
1.1	2.5	1.3	4.3
1.2	2.7	1.4	4.4
1.3	2.8	1.5	4.6

Accordingly, there is shown in table 4 approximately how much calcium diets of different phosphorus content should contain. *If laying chickens are fed diets containing the percentages of calcium and phosphorus shown in this table, additional calcium in the form of oyster shell or limestone grit should not be supplied.*

So far as is known, the salt requirement per pound of feed of laying hens is the same as that for growing chicks. It is desirable to use the same mixture of common salt and manganous sulphate as that recommended for growing chicks because a deficiency of manganese adversely affects both the production of eggs and their hatchability.

Vitamins.—Except in the case of vitamin G, the vitamin requirements of laying stock are as great or greater than those of growing chicks. The following quantities of vitamins per pound of feed are recommended for laying stock, when the eggs are not intended primarily for hatching: 3,150 International Units of vitamin A, 180 International Units of vitamin B, 360 A. O. A. C. chick units of vitamin D, 680 micrograms of vitamin G, and 0.9 modified Jukes-Lepkovsky unit[1] of the chick antidermatosis factor (pantothenic acid).

The nutritive requirements of breeding stock are similar to those of ordinary laying stock. The chief difference is that a somewhat higher vitamin intake is required for the production of eggs of high hatchability. For breeding stock the fol-

*See footnote 4 of Table 11 or footnote 5 of Table 14.

lowing quantities of vitamins per pound of feed are recommended: 4,720 International Units of vitamin A, 180 International Units of vitamin B, 450 A. O. A. C. chick units of vitamin D, 1250 micrograms of vitamin G, and 0.9 to 1.0 modified Jukes-Lepkovsky unit[1] of the chick antidermatosis factor (pantothenic acid).

Market Chickens

Broilers have the same nutritive requirements as other growing chickens. Ordinarily, no special advantage is gained by feeding broilers a special finishing diet; however, if the growing diet contains fish oil or fish meal, it is a good practice to omit them for at least two weeks before the broilers are killed and dressed, otherwise they may cause the flesh of the chickens to have a fishy taste. Nevertheless, experience has shown that some fish meals—notably domestic sardine meals —ordinarily do not affect the flavor of the flesh of chickens, and need not be omitted from the diet at any time.

Sometimes a special finishing diet is fed to broilers during a period of several days before the chickens are killed for the purpose of improving the quality and, hence, the value of the carcass. The nature of the finishing diet is determined by the stage of growth of the chickens. The finishing diet for broilers should contain about 18 per cent of protein (air-dry basis), and it should pos-

[1]See footnote 4 of table 11 or footnote 5 of table 14.

sess all the nutritive properties of a growing diet but need not contain any special source of vitamin D. However, when no source of vitamin D is supplied, it is necessary that the dietary calcium-phosphorus ratio be increased to about 2.3:1 to prevent the development of brittle wing and leg bones.

The finishing diet of roasters, capons, and fowls[1] need not contain more than 14 to 15 per cent of protein. The quantities of the several vitamins, except vitamin A, may be reduced to about one-half of those recommended for growing chicks. It is desirable that the calcium and phosphorus content of finishing diets for these classes of market chickens be about 1.00 and 0.50 per cent, respectively, or in the ratio of about 2 to 1.

Finishing diets that are fed especially for the purpose of improving the quality of carcass should contain between 6 and 10 per cent of fat (air-dry basis). Most mixtures of the usual feed stuffs do not contain this much fat and so it is desirable to add some. Corn oil is an unusually good source of additional fat. Other oils, such as red palm oil, rapeseed oil, and peanut oil may be used when their cost is similar to that of corn oil. Mutton tallow has been used, and is still used at times, but it is not so readily mixed with the feed as are the oils just mentioned. The quantity of oil to add to a finishing diet depends on the fat content of the

[1]A market class which includes mature female birds of any age or weight. See U. S. D. A. Farmers' Bulletin 1377, "Marketing Poultry."

diet; ordinarily, the proper quantity to add is between 2.5 and 6 per cent.

Segregated Breeding Males

When young males to be used for breeding are segregated from the females they should be fed in the same manner as other growing chicks until they are about 9 months old, after which their nutritive requirements are met by a diet which contains about 13 or 14 per cent of protein, 0.4 to 0.6 per cent of phosphorus, and 0.5 to 0.7 per cent of calcium. The quantities of the vitamins per pound of feed may be reduced to 1,200 International Units of vitamin A, 75 A. O. A. C. chick units of vitamin D, and 550 micrograms of vitamin G.

NUTRITIVE PROPERTIES OF FEEDSTUFFS

In the economical feeding of chickens the feedstuffs should be chosen so as to supply all the necessary nutrients in sufficient quantities, but as cheaply as possible. Often the cost of the feed may be appreciably reduced by the simple substitution of one feedstuff for another; however, there are times when a feedstuff can be replaced only by a combination of two or more other feedstuffs. When substitutions are made, the resulting diet should be carefully checked to find out whether or not it contains enough of all the necessary nutrients, especially protein, minerals, and vitamins. The tables at the end of this book will aid materially in making substitutions.

Palatability

Although one feedstuff may have essentially the same nutritive value as another, it may not be so palatable. This should be kept in mind because a reduction of feed consumption will usually result in poorer growth or egg production. Fortunately, however, taste and smell are poorly developed senses in the chicken and palatability is largely dependent on the physical properties of the feed. Thus sight and touch play important roles. Memory may also be an important factor because a feedstuff, or a mixed feed, that has once caused

digestive disturbances or discomfort usually will not be eaten with relish a second time.

Finely ground or sticky feeds are not palatable. When a chicken is offered a choice of several feedstuffs, those that are very finely ground or those that form a sticky mass and are swallowed with difficulty are usually avoided. For example, chickens will not readily eat finely ground alfalfa leaf meal but will eat with relish the leaves from alfalfa hay. A granular, loose-textured mixture of feedstuffs is nearly always quite palatable and, therefore, is to be preferred.

Specific Properties

The feedstuffs in any diet for chickens are frequently chosen on the basis of their ability to serve as sources of one or more specific nutrients. Thus, the cereal grains are chosen as sources of readily digestible carbohydrates but yellow corn is generally preferred to all the others because it is a fair source of vitamin A as well. Dried skim milk is used because it is a relatively good source of vitamin G, pantothenic acid, and protein of excellent quality. In addition to being good sources of animal protein, meat scrap and fish meal supply fairly large quantities of calcium and phosphorus. Bran and middlings are sources of various vitamins, or vitamin-like factors, fiber of suitable quality, miscellaneous minerals, and protein of fair quality. Alfalfa meal and alfalfa leaf meal are good sources of vitamins A and G, and of some other vitamins as well. Cod-liver oil and

other fish oils are usually included in the diet as sources of vitamin D, but may serve to supply the major portion of the vitamin A. And, finally, linseed meal is of value because it supplies small quantities of certain essential fat acids and imparts desirable physical properties to the feed masses in the small intestine and to the excreted fecal masses.

Quality of the Protein

Unless the protein in the diet supplies adequate quantities of all the essential amino acids, the rate of growth or of egg production will be limited in proportion to the inadequacy of any one of these compounds. Usually, proteins of animal origin supply a greater variety and a larger quantity of the essential amino acids than do proteins of plant origin. For this reason, as is pointed out elsewhere in this book, animal proteins are generally of better quality than are plant proteins.

The several protein supplements used in compounding diets for chicks vary considerably in composition and to some extent in their quality. For this reason it is not possible to state their relative values for growth and reproduction in precise terms. Notwithstanding, it is possible to indicate their relative values in a qualitative way, by using a system of numbers in which 1 represents the highest value, 2 the next highest, 3 the next, and so on. In this way the more common protein supplements may be rated as follows:

Dried skim milk	1	Hempseed meal	2
Dried buttermilk	1	Soybean meal	2
Fish meal (best grades)	1	Peanut meal	2-3
Meat scrap	2	Cottonseed meal	3
Fish meal (poorer grades)	2	Linseed meal	4
		Corn gluten meal	4
		Soybeans	4

In practical diets for all classes of chickens, but especially for growing chicks, between 20 and 40 per cent of the total protein should be derived from feedstuffs of animal origin such as dried skim milk, dried buttermilk, meat scrap, or fish meal.

Total Digestible Nutrients

Due to the fact that the urine and feces of chickens are excreted together, considerable difficulty is experienced in determining the digestibility of the various feedstuffs in this species. In much of the earlier work in this field, methods which were not dependable were used and the data so obtained were highly variable. As a result, digestibility data have been used but little by poultry nutrition workers. Gradually there has accumulated, however, a small body of reasonably reliable data on the digestibility of a number of feedstuffs commonly used in feeding chickens.

When properly used, digestibility data are of value in indicating which of several feedstuffs is likely to give the best results when substituted for another. Selected data on digestibility of a small number of feedstuffs are given in table 15 at the

end of this book. In this table there is also given the percentage of total digestible nutrients, when the feedstuffs have the average composition shown in table 12. When the actual composition of a given feedstuff is known to be different from the average composition, the percentage of total digestible nutrients should be recalculated before it is used. However, in the absence of definite information about the composition of a given feedstuff, the data given in the last column of table 15 may be used.

As an example of the application of such data we may consider the desirability of substituting milo for yellow corn in a diet in which the adequacy of the vitamin A content is not dependent on the yellow corn. Inspection of the data in the last column of table 15 shows that both milo and corn supply the same quantity of digestible nutrients. If, under the conditions stated, milo is cheaper than corn, it would be more economical to use it than to continue using corn. On the other hand it would not be economical to substitute wheat for corn unless the wheat were considerably cheaper than the corn. However, inasmuch as some feedstuffs are included in the diet because they possess certain specific properties, it is clear that the quantity of total digestible nutrients cannot be used as the sole criterion in deciding whether or not a proposed substitution should be made.

Relative Value of the Common Cereal Grains

A number of experiments have been conducted in which the common cereal grains have been compared with one another, when they were fed at the same level in otherwise identical diets. The data so obtained indicate that but little difference is to be expected in the gains of growing chicks regardless of which of the cereal grains is used. However, oatmeal is somewhat more efficient in producing gains in live weight than corn, wheat, barley, or whole oats.

For laying hens corn appears to be slightly superior and oats slightly inferior to barley and wheat. On the basis of the gains produced in cage-fattened chickens there is little or no difference between diets containing equal quantities of corn, wheat, oats, and barley; but diets containing oats are not so efficiently utilized as are diets containing the other three grains. There is some evidence, however, that the flesh of chickens receiving corn or barley is superior to that of those receiving wheat or oats.

INDIVIDUAL FEEDSTUFFS

In selecting the ingredients of a diet, it is desirable to have as much information as possible about the individual feedstuffs. Useful information about the proximate chemical composition, the vitamin content, and the digestibility of a number of feedstuffs used in feeding chickens will be found in the tables at the end of this book. Additional information on selected feedstuffs is given in the paragraphs that follow.

Grains, Seeds, and Their By-Products

Wheat, corn, barley, oats, rye, and the grain sorghums, when shipped in interstate commerce, must be inspected and graded according to the official grain standards of the United States. In buying grain for the feeding of chickens poultrymen should take advantage of this fact and buy according to grade. It is not sufficient to ask for just wheat, corn, or any other grain for which standards have been established, the grade should be specified in order to get the quality desired.

In general, the chief criterion is the number of pounds per bushel; in the case of corn and the grain sorghums, the moisture content is also an important factor; and in the case of barley and

oats, the percentage of sound cultivated barley or oats is also used in determining grade.[1]

The grades of wheat are Nos. 1 Heavy, 1, 2, 3, 4, 5, and Sample grade; Grade No. 1 Heavy must weigh 60 pounds per bushel and No. 5, except in the case of hard spring wheats, must weigh 51 pounds per bushel. Grade No. 5 of hard spring wheat need weigh only 50 pounds per bushel. For feeding chickens any of the first five grades may be used but usually, from the standpoints of quality and price, Grade No. 3 is to be preferred.

The grades of corn are Nos. 1, 2, 3, 4, 5, and Sample grade; the corresponding minimum weights per bushel are 54, 53, 51, 48, and 44 pounds, respectively, for the first five grades; and the corresponding maximum limits of moisture content are 14.0, 15.5, 17.5, 20.0, and 23 per cent, respectively. For feeding chickens the first three grades are to be preferred. During the warmer months of the year grade No. 1 should be chosen, if the corn must be ground and stored for a few weeks before it is used, because this grade is less likely to heat and spoil than those of greater moisture content. During the cooler months grades No. 2, and, at times, grade No. 3, are satisfactory.

Barley has the same number of grades as corn. The minimum weights per bushel are 47, 46, 43, 40, and 35 pounds, respectively, for the first five

[1]The reader is referred for further details to Handbook of Official Grain Standards of the United States. (For sale by Superintendent of Documents, Washington, D. C.; price 15 cents.)

grades and the corresponding minimum limits of sound barley are 95, 93, 90, 80, and 70 per cent, respectively, of the total. The first three grades are always to be preferred.

There are five grades of oats, including Sample grade. The minimum weights per bushel are 32, 30, 27, and 24, respectively, for the first 4 grades; and the corresponding minimum limits of sound oats are 97, 94, 90, and 80 per cent, respectively, of the total. There are also several special grades, among which are (1) tough oats which, regardless of weight per bushel, contain more than 14.5 per cent but not more than 16 per cent of moisture, (2) heavy oats which weigh between 35 and 38 pounds per bushel, and (3) extra heavy oats which weigh 38 pounds or more per bushel. The extra heavy or heavy special grades are to be preferred for feeding chickens; tough oats are not satisfactory.

The grade specifications for rye are not given because this grain is not suitable for feeding chickens.

There are five grades of grain sorghums, including Sample grade. The minimum weights per bushel are 55, 53, 51, and 49, respectively, for the first four grades; and the corresponding maximum limits of moisture content are 14, 15, 16, and 18 per cent, respectively. The first three grades are to be preferred for feeding chickens.

Barley.—This grain, if the proper grades are used, is an excellent feedstuff for poultry and is used extensively in those sections of the country

where it is cheaper than corn. It is not so palatable as corn, wheat, or oats unless it is fed from an early age. It ranks well with corn as an ingredient of finishing diets. Some poultrymen believe that better feather growth is obtained with barley than with corn and that it is of some value in preventing cannibalism. When used in mashes it should be finely and evenly ground.

Corn.—Corn is one of the most valuable of grains for feeding poultry. It is palatable and readily digested. Yellow corn is preferred to white corn because the former is a fair source of vitamin A whereas the latter contains virtually none. Old corn is not so desirable as new corn of proper moisture content. If stored for a long time—a year or more—yellow corn tends to lose its vitamin A potency. When used in laying mashes, corn should be coarsely but evenly ground; in mashes for growing chicks it should be somewhat more finely ground. Argentine (flint) corn has essentially the same nutritive value as the native dent corn and is just as suitable for feeding chickens.

Corn gluten meal.—This is the part of the corn that remains after the larger part of the starch and germ is removed in the manufacture of corn starch or corn syrup. Sometimes it may contain some corn oil meal. If made from yellow corn, it is a good source of vitamin A. Although it is rich in protein, the protein is not of particularly good quality and is inferior to that of soybean meal or cottonseed meal. It is of special value as a protein supplement to cereal grain mixtures intended to be

fed to growing chicks when liquid skim milk is used as the sole source of animal protein.

Cottonseed meal.—Because of its undesirable effects on the color of the yolk of the eggs, cottonseed meal should not be fed to laying chickens. However, for growing chicks it is a good plant-protein supplement but ranks somewhat below soybean meal.

Linseed meal.—As a plant-protein supplement linseed meal ranks between cottonseed meal and corn gluten meal. Its chief value lies in the fact that in its passage through the alimentary tract it absorbs a fairly large quantity of water and tends to form a somewhat bulky, mucilaginous mass which aids in the passage of feed residues through the intestines and tends to yield a coherent fecal mass. If more than 4 or 5 per cent is included in the diet it tends to have a laxative effect and for this reason the quantity fed should be restricted to, preferably, about 2 per cent. Linseed meal also supplies small quantities of certain essential fat acids. Some poultrymen believe that it tends to improve the general appearance of the feathers.

Milo and the other grain sorghums.—The grain sorghums are similar to corn in their general nutritive properties but usually are not so palatable. Yellow milo is generally preferred to the kafirs, the durras and the other milos. The grain sorghums may be used as a part of the grain or, when properly ground, in the mash.

Oats and oatmeal.—Oats are an excellent and palatable feedstuff for chickens, and are reputed

to be of value in preventing cannibalism and feather picking. They are a good source of the anti-gizzard-erosion factor. When used in mashes they should be very finely ground. Finely pulverized oats tend to prevent the development of rancidity and, therefore, are reputed to be of value in preventing the destruction of vitamins A and E. Rolled oats, or oatmeal, is highly prized as an ingredient of diets for growing chicks Both ground oats and oatmeal are valuable ingredients of finishing diets.

Peas and beans.—Cow peas, garden peas, field peas, navy beans, and pinto beans are all rich in protein of a type that makes them good protein supplements to the cereal grains. Garden peas are a fair source of vitamin A and pinto beans are a good source of vitamin B_1. Peas and beans are not widely used because of their relatively high price as compared with that of soybeans and soybean meal.

Peanut meal.—Peanut meal is a good source of protein which, as in the case of peas and beans, supplies some of the amino acids that are lacking in the cereal grains. It is a good source of the chick antidermatosis factor.

Rice.—Rice is a very palatable and highly digestible cereal but is not widely used because of its relatively high cost. When available at a suitable price, it is an excellent ingredient of chick diets.

Soybeans and soybean meal.—Soybeans are not widely fed to chickens. During recent years soy-

bean meal has come into rather wide use as an ingredient of diets for both growing and laying chickens. Soybean meal is generally considered as the best available source of plant protein. The protein of soybean meal is of high quality and ranks well with that of the ordinary grade of meat-and-bone scrap; however neither the beans nor the meal should be used as the sole protein supplement.

Wheat.—At one time wheat was very widely used in the feeding of chickens and was highly prized for this purpose but due to its relatively high cost it is not so widely used as formerly. It is very palatable.

Wheat bran.—This by-product of the milling of wheat is widely used in feeding all classes of chickens. It has a rather low digestibility and, hence, a low nutritive value. However, the value of bran is dependent in part on its physical properties. It supplies bulk and improves the texture and palatability of a mixed feed. It is a good source of the anti-gizzard-erosion factor.

Wheat middlings and shorts.—These two products are very similar both in chemical composition and nutritive value. In general they consist of the fine particles of bran together with a very small quantity of the fibrous offal obtained from the "tail of the mill". They also contain some wheat germ but the quantity present in some lots tends to be much less than formerly because new and more profitable markets have been found for

wheat germ. Wheat middlings and shorts contain less crude fiber and are somewhat more digestible than wheat bran. They are very widely used in the feeding of chickens at all stages of development. Their value is dependent in part, as is that of bran, on their physical properties.

Feeds of Animal Origin

Beef scrap.—Beef scrap of the best grade is one of the most valuable animal-protein supplements used in feeding chickens; it ranks well with dried skim milk, buttermilk, and fish meal. It contains rather appreciable quantities of calcium and phosphorus.

Dried buttermilk and dried skim milk.—These two products are the best available sources of protein of high quality for feeding chickens. In general, dried skim milk is more uniform in composition and quality than is dried buttermilk. Both are good sources of nearly all the mineral elements, excepting iron. Both are good sources of vitamin G and pantothenic acid.

Substitutes for milk.—When dried skim and dried buttermilk are not available or when their cost is disproportionately high in comparison with that of other feedstuffs, it may be more economical to use substitutes. However, *no complete substitute for milk has been found as yet.* but it is possible to devise substitutes that are almost as good. In general, the suitability of a substitute for milk depends largely on its content of (1) protein of high quality, (2) vitamin G, or riboflavin,

and (3) pantothenic acid, or the chick antidermatosis factor.

One of the best substitutes for dried skim milk or dried buttermilk is a mixture of 40 parts, by weight, of high-grade fish meal and 60 parts of dried whey. About 5.8 pounds of this mixture will take the place of 5 pounds of dried skim milk. Another good substitute—and usually a much cheaper one—is a mixture of 15 parts of sardine meal and 85 parts of dehydrated alfalfa leaf meal. However, 6.5 pounds of this substitute must be used for each 5 pounds of dried skim milk or dried buttermilk that is replaced. If fish meal of good quality is not available at a reasonable price, a mixture of 10 parts of meat scrap, 10 parts of soybean meal, and 80 parts of dehydrated alfalfa leaf meal may be used; but in this case it will be necessary to use 7.0 pounds for each 5 pounds of dried skim milk or dried buttermilk that is replaced.

Fish meal.—There are a large number of different kinds of fish meal. Three different methods are used in drying the materials used in making fish meal and, according to the method used, the resulting products are known as vacuum-dried, steam-dried, and flame-dried fish meals. The best grades are either vacuum or steam-dried and their protein is of high quality. The quality of the protein of the best grades ranks well with that of dried skim milk and buttermilk. The calcium content varies from about 3.5 to 10.5 per cent and the phosphorus content from about 2.5 to 5.0 per cent.

Meat scrap and meat-and-bone scrap.—These products are valuable sources of animal protein but the quality of their protein ranks somewhat below that of dried skim milk and dried buttermilk. Their calcium and phosphorus content is similar to that of fish meal but it is usually somewhat greater.

Dried whey.—Dried whey is now fairly widely used in feeding chickens. It is particularly valuable as a source of vitamin G and pantothenic acid; however, it contains about 12 per cent of protein of very good quality and between 8 and 9 per cent of a good assortment of the mineral elements found in milk.

Green Feeds, Etc.

Alfalfa meal and alfalfa leaf meal.—These are two very important feedstuffs for poultry although they supply appreciably less digestible nutrients than bran. Their value lies in the fact that when they are properly prepared they are very good sources of vitamins A, C, E, G, and K. They also are fair sources of vitamin B_1, the chick antidermatosis factor, the anti-gizzard-erosion factor, and, if sun-cured, may supply a small quantity of vitamin D. Alfalfa meal and alfalfa leaf meal should always be bought on grade in order to insure getting products of good quality. There are no official grades for these feedstuffs but tentative standards have been set up by the U. S. Bureau of Agricultural Economics. According to these tentative standards, alfalfa leaf meal is required to

contain 85 per cent or more of leaf particles and not less than 19 per cent of protein, and special alfalfa meal is required to contain 60 per cent or more but less than 85 per cent of leaf particles, and not less than 16 per cent of protein. These products may be obtained in four different grinds: extra fine, fine, medium, and coarse. The grade is determined by the greenness. In the order of decreasing greenness the grades are: Extra green, No. 1, No. 2, No. 3, and Sample grade. In order to get products of the best quality, one of the two following specifications should always be used: (1) U. S. Extra green, medium alfalfa leaf meal or (2) U. S. Extra green, medium special alfalfa meal.

Carrots.—Yellow carrots are a good source of vitamin A. They may be stored in suitable cellars for use when green feed is scarce.

Kale.—Kale is widely used as a green feed in some sections of the country. It is rated as a good source of vitamins A, B, and G.

Yeast and cereal-yeast feeds.—Yeast, especially brewer's yeast, is an excellent source of vitamins B and G but it is usually too expensive to use in feeding poultry. During recent years less expensive yeast products, known as cereal yeast feeds, have been placed on the market. They should be used only when their vitamin G content is as great as, or greater than, that of dried skim milk and their cost somewhat less.

Calcium and Phosphorus Supplements

The two best sources of calcium for use in the feeding of chickens are high-calcium limestone and oyster shell. Crab shell, when properly dried, is also a very good source of calcium but it is available in only a relatively few sections of the country. When a source of both phosphorus and calcium is required, steamed bone meal may be used.

Miscellaneous Materials

Salt.—Either common salt or iodized salt may be used. It should be finely granular and free flowing. Care should always be taken to break up any lumps that may be present.

Grit.—River gravel and native pebbles make the best grit; however, other insoluble, nonfriable rock materials may be used. Fine sand is of no value as grit because it readily passes through the gizzard but coarse sand may be used as grit for young chicks.

Charcoal.—Charcoal is of little or no value in the feeding of chickens.

Sulphur.—From the standpoint of nutrition, sulphur is of little or no value. However, recent work indicates that it may be of some value in combating coccidiosis. If used for this purpose, the quantity should be restricted to 2 per cent and the quantity of vitamin D in the feed mixture should be doubled to prevent the development of so-called sulphur rickets. In no case is it a good practice to include sulphur in the diet of growing

chicks for a period longer than three or four weeks.

Mineral mixtures.—It is not possible to prepare a complete mineral mixture that is suitable for use in all diets. The use of so-called complete mineral mixtures is not recommended. Recent experimental results indicate, however, that it is feasible to add small quantities of manganous sulphate, ferrous sulphate and copper sulphate to common salt and use the resulting mixture in place of common salt. The following is suggested as a suitable mixture:

	Parts, by weight
Common salt	100.0
Manganous sulphate (anhydrous)[1]	1.7
Ferrous sulphate	2.0
Copper sulphate	0.08
Total	103.78

[1]Or 2.5 parts of manganous sulphate (tetrahydrate), or an equivalent quantity (on the basis of manganese content) of any of the other forms of manganous sulphate or chloride.

DEFICIENCY DISEASES AND VICES

Poor growth, poor production, many diseases, and heavy mortality are often the indirect result, and sometimes the direct result, of nutritional deficiencies. In general, properly fed birds grow well, lay well, and are healthy. It is important, therefore, that the poultryman be able to recognize the symptoms of nutritional deficiencies.

Many nutritional deficiencies produce the same general symptoms. Satisfactory growth cannot be obtained on a diet deficient in minerals, protein, or vitamins, or when the total energy intake is insufficient. An insufficient quantity of any one of the mineral elements, amino acids, or vitamins may retard growth. For example, good growth cannot be obtained if the diet is markedly deficient in sodium, even though all the other necessary mineral elements, as well as the amino acids and vitamins, are present. For these reasons it is not always possible to recognize the cause from the symptoms. However, some deficiencies produce more or less characteristic symptoms and these will be discussed briefly.

Vitamin A Deficiency

Nutritional roup is a disease caused by a deficiency of vitamin A. It may appear in chickens of any age. The symptoms are a cessation of growth in young chickens, lameness or a stagger-

ing gait, discharge from the nostrils, swelling beneath the eyes, and discharge from the eyes; in severe cases blindness and, finally, death result. Examination after death shows swollen follicles in the esophagus, pale kidneys, and frequently white accumulations (urates) in the kidneys and ureters.

Vitamin B_1 Deficiency

Polyneuritis is a condition caused by a deficiency of vitamin B_1 and may occur in chickens of any age. It is characterized by loss of appetite, emaciation, general weakness and inability to stand, and spasmodic movements of the head and legs. Death eventually ensues, if vitamin B_1 is not supplied.

Vitamin D Deficiency

Rickets is a disease of the bones of growing chickens that is most commonly caused by a deficiency of vitamin D. It may also be caused by a marked deficiency of either calcium or phosphorus. The symptoms are poor growth, lameness accompanied by a stiff-legged gait, thickness of the leg bones and of the hock joints and beading at the ends of the ribs. Spinal curvature and crooked breast bones also may be observed.

In mature birds the symptoms of vitamin D deficiency are not so obvious; however, a careful examination will show that the breast bone and the ribs have become less rigid than normal. In laying stock the first symptom of a deficiency of vita-

min D in the diet is a thinning of the shells of the eggs. If the deficiency is sufficiently marked, it causes a decrease in both egg production and hatchability.

Vitamin E Deficiency

There is evidence that encephalomalacia, or "crazy chick disease", is caused by a deficiency of vitamin E. The popular name of this disease is very descriptive of the symptoms: the chicks act crazily. When they attempt to walk, they often fall forward or backward or on one side and then wheel in circles. In advanced cases there frequently is complete prostration with the legs extended, the head sometimes retracted, and tremors of both head and legs. Preventing this disease is quite simple, all that is necessary is to include in the diet a small quantity (1 to 2 per cent) of vegetable oil, such as corn oil, cottonseed oil, peanut oil, or soybean oil.

Vitamin G Deficiency

The symptoms formerly attributed to a deficiency of vitamin G or the so-called vitamin G complex appear to have been caused by a deficiency of several associated factors. The only definite results of a deficiency of vitamin G (riboflavin) are a retardation of the growth of chicks and a decrease in the hatchability of eggs; however, there is good evidence that a deficiency of vitamin G causes a twisted or flexed condition of

the toes which sometimes is referred to as "curled-toe" paralysis.

Vitamin K Deficiency

A deficiency of vitamin K is readily recognized by the hemorrhages that occur under the skin and throughout the various tissues of the body. Laboratory tests show a marked increase in the time required for the blood to clot.

Pantothenic Acid Deficiency

A deficiency of pantothenic acid (chick antidermatosis factor) in the diet causes a condition known as chick dermatosis. The symptoms of a deficiency of this factor are sores and incrustations at the corners of the eyes and mouth, on the bottoms of the feet, and sometimes on the joints of the toes. Also, the feathering is rough and there is a failure of growth. Until 1939, the factor that prevents chick dermatosis was called the chick antidermatosis factor, or filtrate factor.

Gizzard Erosion

There are no external symptoms of the condition known as gizzard erosion. This condition can be diagnosed only after the chicken dies or is killed. It is caused by hemorrhages from the submucosal capillaries. In mild cases brown stains appear in the gizzard lining; in more advanced cases clots of blood are found just under the lining, usually under the stained places; in the more

severe cases there are holes in the lining and these frequently contain a brown débris derived from old blood clots.

Manganese Deficiency

Perosis (slipped tendon, or hock disease) is a condition of the legs that is caused by a deficiency of manganese in the diet. The gross symptoms are an enlargement of the hock joints, bending and twisting of the leg bones, and, in advanced cases, a slipping of the tendons from their normal positions.

If the diet of laying chickens is deficient in manganese, the shells of the resulting eggs tend to be thin and the development of the contained embryos is abnormal and hatchability is reduced. The abnormal condition of the embryos is characterized by a shortening of the leg bones and the development of parrot-like beaks. If the diet of both the growing and laying stock contains about 50 parts per million of manganese, perosis is not likely to occur and the number of cases of abnormal development of the embryos is likely to be much smaller than usual.

Salt Deficiency

Diets for chickens are more frequently deficient in salt than is ordinarily realized. Two rather common vices, feather picking and cannibalism, are sometimes caused by a deficiency of common salt (sodium chloride). When the cause is a de-

ficiency of salt in the diet, these vices can be stopped almost overnight by adding 0.5 to 2.0 per cent of common salt for four or five days to the feed that is being fed.

Although a deficiency of salt is one of the most common causes of feather picking and cannibalism, there is some evidence that at times other factors may be involved. For example, if the chickens are over-crowded, they show a greater tendency to pick each other than if they are given plenty of space. Also, it has been reported that if the diet contains about 20 per cent of barley or oats or large quantities of wheat bran the tendency of the chickens to pick one another is greatly reduced.

When feather picking and cannibalism appear in a flock, the first remedial measure to try is the inclusion of additional salt in the diet. If this fails, it may be necessary to trim the upper mandible of beaks of the chickens back to the quick. This is best done with a sharp knife or a hot soldering iron. Usually, only about three-sixteenths of an inch of the tip of the upper mandible is removed; the proper amount can be judged readily by the appearance of the beak substance.

Egg Eating

Egg eating is a vice that is likely to develop as a result of overcrowding. The tendency to eat eggs is markedly stimulated by a deficiency of calcium in the diet. It has also been observed that the vice is likely to develop when the diet does not contain enough vitamin D.

QUALITY OF FLESH AND EGGS AS AFFECTED BY DIET

During recent years there has been a steadily increasing demand by consumers for the better grades of table poultry and eggs. Inasmuch as the better grades almost invariably command appreciably higher prices than the less desirable grades, it behooves the poultryman to produce products of the best quality. If eggs and meat of the best quality are to be obtained and if the greatest profit possible is to be realized, the chickens must be properly fed, and feedstuffs that have an undesirable effect on the resulting products must be avoided or at least used with caution.

Flavor of Chicken Flesh and Eggs

Although the feed consumed has only a slight effect on the proximate chemical composition of eggs, certain feedstuffs, such as onions, rape, turnips, and some fish meals, have been reported to have an undesirable effect on the flavor, if they are fed in excessive quantities. On the other hand, both the proximate chemical composition of chicken flesh and its flavor may be affected by the feed.

Fishy flavor.—Sometimes the flesh of chickens is found to have an undesirable flavor described as "fishy". Such a flavor may be observed even

though the feed contained no fish oil or fish meal; however, when such a flavor is encountered, it will usually be found that fish oil or fish meal or both have been fed up to the time the chickens were killed. According to the information available, compounds that have a highly undesirable fishy odor and flavor may be produced by the interaction or combining of certain free fat acids and trimethylamine oxide which is commonly present in fish meal. Apparently, also, there are in some plants certain nitrogen-containing compounds, known as betaines, that may also combine with these free fat acids and yield products that have a fishy odor and flavor.

In order to prevent the occurrence of fishy flavor in chicken flesh it is recommended that rancid feedstuffs never be fed and that all fish oil and fish meal be removed from the diet at least two weeks before the chickens are killed. Furthermore, special care should be taken never to kill chickens while there is still some feed in their crops. If feed is retained in the crop, rancidity is likely to develop and the resulting free fat acids may combine with any trimethylamine oxide or betaine present and thus produce undesirable flavors.

Experience has shown that not all fish meals produce a fishy flavor, and that certain ones, such as domestic sardine meal, ordinarily may be fed up to the time the chickens are killed without having any undesirable effects, provided care is taken not to kill the chickens while there is still feed in the

crop. The best procedure to follow is to fast the birds for about 12 to 16 hours before they are killed.

When undesirable flavors are found in eggs, it is best to examine a few eggs from each chicken in the flock because an occasional bird produces eggs that have an objectionable odor or flavor regardless of the kind of feed consumed. If chickens that produce off-flavored eggs are found, they should be removed from the laying flock.

Desirable flavors.—It has not been found possible to improve the flavor of normal eggs by including special feeding stuffs in the diet but there is some evidence that the flavor of the flesh of chickens being finished for market can be improved in this way. For example, it has been reported that adding 2 to 4 per cent of corn oil to the finishing diet (air-dry basis) produces a very satisfactory flavor and that adding a similar quantity of peanut oil produces a flavor described as "sweet".

Color of Flesh and Yolk

Although the color of the flesh of chickens is primarily a breed characteristic, it may be affected to a certain extent by the diet. If large quantities of yellow corn are fed, the color of the fat tends to be yellow. Feeding corn gluten meal and alfalfa leaf meal also tends to increase the yellowness of the fat. The writer has obtained some evidence that corn oil is of value for increasing the quantity of pigment in the shanks and skin of the

yellow-skin breeds. To get the maximum effect it is necessary to include it in the diet only during the last 2 or 3 weeks before the chickens are marketed. About 2 per cent was found to be effective in some cases, but in finish feeding more may be desirable (see tables 7 and 8). When it is desired to produce white-fleshed poultry, yellow corn, corn gluten meal, and green feeds should be omitted from the diet, and oats and white corn should be used in place of the yellow corn and soybean meal in place of corn gluten meal.

In general the color of egg yolks may be easily controlled by feeding suitable feedstuffs. Very light colored yolks may be obtained by eliminating green feed from the diet and by replacing the yellow corn with oats and white corn. The richer shades of yellow may be obtained through the use of yellow corn and alfalfa leaf meal; and deep orange-red yolks may be obtained by feeding 0.5 to 2 per cent of ground pimento pepper or chili pepper. Cull peppers should be used because of their relative cheapness. The use of these cull peppers is not restricted, however, to the production of deeply colored yolks. In the winter when green feed is scarce, or not to be had at all, small quantities may be used for building up the yolk color.

Incidentally, the color of the white of eggs also may be affected by diet. A plentiful supply of green feed tends to give the white a greenish yellow, or whey, color. Rich sources of vitamin G also tend to produce this greenish-yellow color.

Cottonseed meal has an undesirable effect on the color of both the yolk and the white. If large quantities of cottonseed meal are fed, the yolks of the eggs have a brown mottled appearance when laid. And, even if small quantities are fed, the yolk of the eggs tend to acquire a similar appearance after the eggs have been in cold storage for 6 weeks or longer. Cottonseed meal and weeds of the same botanical family as the cotton plant tend to produce a pink tint in the white.

Vitamin and Fat Content of Eggs

The vitamin content of eggs is readily influenced by the diet of the chickens. The content of vitamins A, B, G, and D can be increased by feeding suitable, rich sources of these vitamins. The vitamin A content appears to be most easily increased.

It is possible to soften the fat of egg yolk by feeding hempseed and other feedstuffs that contain the same type of fat but it has not been found possible to obtain a harder fat than that normally present.

SYSTEMS OF FEEDING

There are numerous systems and methods of feeding chickens. Some systems yield better results under certain conditions than others, either because they tend to insure better nutrition or because they save labor. However, it is much more important to supply the chickens with adequate quantities of all the necessary nutrients than it is to follow a given system. Any system that insures, through design or by accident, an adequate supply of all the necessary nutrients is sure to be successful from the standpoint of nutrition. On the other hand, any system that ignores the principles of sanitation and economics may fail, no matter how well the chickens are nourished.

Housing and Management

When chickens are kept without access to the soil and sunshine, greater attention must be given to their diet than when they are not so kept. This is accounted for in part by the fact that sunshine may serve as a source of vitamin D, and green growing grass and other plants may serve as sources of all the vitamins except Vitamin D. Furthermore, chickens that have access to the soil are less likely to suffer from a deficiency of many of the mineral elements, for example, manganese, than are those that are kept off the soil.

It is a common practice to confine laying stock in laying houses during the fall, winter, and early spring, or even throughout the year. Usually the laying houses have open fronts and the chickens have access to some sunshine, but in some cases the chickens receive no sunshine during the entire period they are in laying quarters. In the one case the birds receive the equivalent of at least a part of their vitamin D requirements from sunshine and in the other they receive none. Nevertheless, in both cases the diet should supply at least the minimum quantity of vitamin D required by laying chickens in order to prevent a partial deficiency of this vitamin.

Even when the chickens have access to range, they may not get enough green feed to insure an adequate supply of vitamins A and G, if their diets are deficient in these important nutritive factors. Thus, it is obvious that methods of housing and management may determine whether a given diet is adequate or not, unless care is taken to furnish at least the minimum requirements of all the known essential nutritive factors.

Methods of Feeding

The various methods of feeding chickens involve the use of one or more of the following combinations of feedstuffs: (1) mash, wet or dry; (2) grain, cracked or whole; and (3) pellets. In addition, liquid skim milk or buttermilk may be given the chickens to drink and green feed may be supplied. When nothing but a dry mash is fed,

the method of feeding is known as the all-mash, or all-in-one method; when both a dry mash and grain are fed, it is known as the mash-grain, or mash-scratch method. The feeding of pellets is obviously a modification of the all-mash method. In addition to these three methods, various combinations are used. A somewhat novel method, known as the self-selection, or cafeteria method, is sometimes used. In this method the chickens are given access to a fairly large number of selected feedstuffs in individual hoppers and are allowed to eat as much of each one as they will.

The most commonly used method is the mash-grain method but during recent years the all-mash and pellet methods have come into wider use because of their great simplicity. Various opinions have been expressed about the self-selection methods but the evidence seems to be that it is not entirely satisfactory. In any case, the individual poultryman should be guided by his past experience and should use that method with which he has been most successful. The novice will usually find the all-mash method quite satisfactory.

It is a common practice when grain or a scratch mixture is used, to feed it in the litter in order to give the birds some exercise in obtaining this portion of their feed. Experience in feeding chickens in batteries indicates that the value of this exercise has been very much overrated. In any case feeding grain in the litter is to be condemned as being insanitary. The better practice is to feed all grain, or so-called scratch feed, in hoppers.

FORMULAS OF DIETS

In formulating diets for any class of chickens, careful attention should be given to the selection, preparation, and mixing of the several ingredients. Only suitable grades of each feedstuff should be used. Except in the case of oats, barley, and feedstuffs that contain considerable fiber, extremely fine grinding of the ingredients should be avoided. A granular, loose-textured mixture is to be preferred but, of course, the feed of very young chicks should be finer than that of adult stock.

Mixing the Ingredients

All the ingredients should be carefully mixed to insure an even distribution of those that may be present in rather small quantities, such as salt, ground limestone, oyster shell, cod-liver oil, and other fish oils. The more bulky ingredients and those that are to be used in great quantity should be weighed out first, no matter whether the mixing is done on a smooth floor or in a mechanical mixer, and then the other ingredients added. The salt and other mineral supplements may be mixed first with one of the other ingredients and then added. It is not a good practice to mix cod-liver oil or other fish oils with the mineral ingredients. All oils should first be mixed thoroughly with a portion of the bran or ground corn before they are

added. If pulverized or very finely ground oats are included in the diet, it is preferable first to mix the oil with them because they serve as an antioxidant and, thus, are of some value in preventing destruction of the vitamin A in the oil. When the mash-grain method of feeding is used, an alternate method of feeding the cod-liver oil is to mix a suitable quantity with a portion of the grain each day and feed the resulting mixture late in the afternoon.

Succulent and Fresh Green Feeds Not Necessary

Most of the older systems of feeding required the use of succulent and fresh green feeds. Research has shown, however, that such feeds are not necessary so long as the diet supplies all the essential nutritive factors in adequate quantities. This does not mean that they should not be used but suggests that the nutritive factors supplied by such feeds may be obtained more economically in other ways. For example, the best grades of alfalfa leaf meal and alfalfa meal may be used in place of fresh, green feed; and it usually will be found that their use is more economical and the results are just as satisfactory.

All-Mash Diets

The suitability and value of all-mash diets in the feeding of growing chickens are generally conceded. Such diets also are suitable and valuable for the production of table and hatching eggs of

uniform quality and hatchability. The following all-mash diets will be found satisfactory for the feeding of caged and confined chickens as well as those that have access to sunshine and green range.

Diets for growing chickens.—The all-mash diets given in table 5 are suitable for the production of broilers and for raising breeding stock. These diets may be fed also to capons until they are about 3 months old, after which, for the sake of economy, the protein content may be reduced by the addition of gradually increasing quantities of ground grain until the grain constitutes as much as 60 per cent of the resulting mixture. Pullets may be kept on these diets until within about 2 or 3 weeks of the time egg production is expected to begin, at which time a suitable laying diet should be gradually substituted for the starting and growing diet. Segregated breeding males may be fed these diets until they are about 9 months old, after which they may be fed diets containing considerably less protein, minerals, and vitamins.

Numerous substitutions may be made in compounding the diets in table 5. For example, ground grain sorghums and cereal grains, singly or mixed, may be substituted for the yellow corn in any of the first four diets. Dried buttermilk may be used in place of dried skim milk in any of the diets; meat scrap, meat-and-bone scrap, and fish meal may be used interchangeably; cottonseed meal may be substituted for soybean meal; special alfalfa meal may be used instead of alfalfa leaf meal;

Table 5. All-mash starting and growing diets.

Ingredient	KIND AND PROPORTION OF FEEDS IN DIETS						
	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5	Diet 6	Diet 7
	Parts by weight	Parts by weight	Parts by weight	Parts by weight	Parts by weight	Parts by weight	Parts by weight
Ground yellow corn	31.0	30.0	34.5	39.0	40.4	32.0	.....
Ground wheat	.....	.....	.....	.....	22.5	.....	.....
Finely ground oats	10.0	10.0	.....	10.0	.....	.....	.....
Finely ground barley	.....	.....	.....	.....	.....	.....	63.0
Wheat middlings	20.0	10.0	35.0	16.0	.....	20.0	.....
Wheat bran	6.0	10.0	.....	.....	.....	15.0	.....
Dried skim milk	6.0	10.0	7.0	10.0	10.0	5.0	8.0
Meat scrap	5.0	10.0	15.0	.....	10.0	5.0	7.0
Meat-and-bone scrap	.....	.....	.....	5.0	.....	.....	.....
Fish meal	5.0	.....	.....	5.0	.....	5.0	.....
Alfalfa leaf meal	7.0	8.0	7.0	5.0	5.0	5.8	7.0
Soybean meal	6.0	10.0	.....	.....	.....	5.0	.....
Corn gluten meal	.....	.....	.....	.....	11.0	5.0	13.0
Cottonseed meal	.....	.....	.....	8.0	.....	.....	.....
Linseed meal, old process	2.0	.....	.....	.....	.....	.....	.....
Ground limestone	1.0	1.0	.5	1.0	.5	1.0	.5
Special steamed bonemeal	.....	.....	.....	.....	.....	.....	.5
Salt[1]	.5	.5	.5	.5	.5	.7	.5
Cod-liver oil	.5	.5	.5	.5	.5	.5	.5
ESTIMATED CONTENT OF VARIOUS NUTRITIVE CONSTITUENTS IN DIETS							
	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent
Protein	21.0	22.0	21.2	20.8	21.3	21.7	21.1
Calcium	1.40	1.56	1.69	1.47	1.26	1.46	1.21
Phosphorus	.87	.92	1.11	.92	.75	.96	.72
Crude fiber	5.5	5.5	4.6	4.4	2.7	4.9	5.4

[1] The salt mixture given on page 44, or one containing about the same quantity of manganese, should be used; otherwise perosis may occur among the chicks.

ground oyster shell is just as suitable as ground limestone; and sardine oil that contains at least 38,560 A. O. A. C. chick units of vitamin D per pound (85 A. O. A. C. chick units per gram) may be used in place of the cod-liver oil. If a high-potency or a so-called fortified cod-liver oil is used in place of ordinary cod-liver oil, less will be required, and the quantity used should depend on the vitamin D potency guaranteed by the manufacturer.

Diets for laying and breeding stock.—The results of studies of the effect of diet on the hatchability of eggs have shown that when eggs are to be used for hatching, it is necessary to feed a diet that contains somewhat more of most of the vitamins than when the eggs are to be used for other purposes. (See table 11.) Furthermore, there is some evidence that the eggs of chickens that lay a large number tend to have a higher hatchability than those of chickens that lay a considerably smaller number. These observations lead to the conclusion that it is best at all times to feed laying chickens diets that will permit them to produce eggs of high hatchability, no matter whether the eggs are to be used for hatching or not. All the diets given in table 6 are formulated for the production of eggs of high hatchability; however, good egg production may be obtained with diets that are made up to contain the quantities of vitamins A, D and G indicated for laying stock in table 11.

Table 6. All-mash diets for laying and breeding stock.

Ingredient	KIND AND PROPORTION OF FEEDS IN DIETS						
	Diet 8	Diet 9	Diet 10	Diet 11	Diet 12	Diet 13	Diet 14
	Parts by weight	Parts by weight	Parts by weight	Parts by weight	Parts by weight	Parts by weight	Parts by weight
Ground yellow corn	37.1	40.9	38.4	43.9	46.1	39.1	.....
Ground wheat	.....	.....	.....	.....	22.5	.....	.....
Finely ground oats	10.0	10.0	.....	10.0	.....	.....	.....
Finely ground barley	.....	.....	.....	.....	.....	.....	70.0
Wheat middlings	20.0	10.0	35.0	16.0	.....	20.0	.....
Wheat bran	6.0	10.0	.....	.....	.....	15.0	.....
Dried skim milk	5.0	5.0	6.0	5.0	6.0	5.0	7.0
Meat scrap	2.0	4.0	6.0	.....	4.0	2.0	3.0
Meat-and-bone-scrap	.....	.....	.....	2.0	.....	.....	.....
Fish meal	2.0	.....	.....	2.0	.....	2.0	.....
Alfalfa leaf meal	7.0	7.0	7.0	7.0	5.0	6.0	7.5
Soybean meal	2.5	4.5	.....	5.0	.....	2.0	.....
Corn gluten meal	.....	.....	.....	.....	7.5	2.0	3.0
Linseed meal, old process	2.0	2.0	2.0	2.0	2.0	.....	2.0
Ground limestone	3.3	3.0	3.5	2.5	2.3	3.5	1.9
Special steamed bonemeal	1.0	1.5	.....	2.5	2.5	1.0	3.5
Salt[1]	.7	.7	.7	.7	.7	1.0	.7
Cod-liver oil	1.4	1.4	1.4	1.4	1.4	1.4	1.4
ESTIMATED CONTENT OF VARIOUS NUTRITIVE CONSTITUENTS IN DIETS							
	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent
Protein	16.2	16.3	16.1	16.3	16.5	16.5	16.1
Calcium	2.14	2.22	2.11	2.33	2.21	2.22	2.36
Phosphorus	.79	.86	.76	.97	.86	.87	.99
Crude fiber	5.4	5.3	4.6	4.4	3.1	4.8	5.8

[1] The salt mixture given on page 44, or one containing about the same quantity of manganese, should be used; otherwise the hatchability may be adversely affected.

Several substitutions may be made in the diets given in table 6. If it is desirable to reduce the color of the yolks produced when diets 8 to 13, inclusive, are fed, white corn may be substituted in whole or in part for the yellow corn, provided (1) that the alfalfa leaf meal is of the best quality, (2) that the cod-liver oil contains at least 385,550 International Units of vitamin A per pound and (3) that each batch of mixed feed is fed within three weeks after it is made up. Under the same conditions, the other cereal grains and the grain sorghums may also be substituted for the yellow corn. Dried buttermilk may be used in place of dried skim milk; meat scrap, meat-and-bone scrap, and fish meal may be used interchangeably; special alfalfa meal may be used instead of alfalfa leaf meal; ground oyster shell is as satisfactory as ground limestone; and sardine oil that contains at least 385,550 International Units of vitamin A and 38,560 A. O. A. O. chick units of vitamin D per pound may be used in place of the cod-liver oil. In the absence of legal standards for the vitamin A content of sardine oil, and inasmuch as sardine oil contains much less vitamin A than cod-liver oil, sardine oil should be used in place of cod-liver oil in the diets in table 6 only when the manufacturer definitely guarantees the vitamin A content to be not less than 385,550 International Units per pound. However, if the sardine oil contains less than this quantity of vitamin A it may be used in place of cod-liver oil, if a proportionately larger quantity is taken. If high potency or

Table 7. Finishing diets for broilers.

Ingredients	KINDS AND PROPORTION OF FEEDS IN DIETS						
	Diet 15	Diet 16	Diet 17	Diet 18	Diet 19	Diet 20	Diet 21
	Parts by weight	Parts by weight	Parts by weight	Parts by weight	Parts by weight	Parts by weight	Parts by weight
Ground corn	40.4	38.4	20.4	.....	.....	.....	16.0
Finely ground barley	30.0	.....	.....	30.0	.....	30.4	.....
Finely ground oats	.....	32.0	30.0	.....	30.9	.....	31.0
Ground wheat	.....	.....	20.0	41.7	31.0	31.0	16.0
Corn gluten meal	.....	.....	.....	.....	15.0	15.0	14.0
Meat scrap	13.0	13.0	13.0	11.0	.....	.....	.....
Dried buttermilk	7.0	7.0	7.0	7.0	10.0	10.0	10.0
Alfalfa leaf meal	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Corn oil	2.5	2.5	2.5	3.0	3.5	4.0	3.5
Special steamed bonemeal	.....	.....	.....	.....	2.0	2.0	2.0
Ground limestone	1.6	1.6	1.6	1.8	2.1	2.1	2.0
Salt	.5	.5	.5	.5	.5	.5	.5
Water[1]							
ESTIMATED CONTENT OF VARIOUS NUTRITIVE CONSTITUENTS IN DIETS (DRY-FEED BASIS)							
	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent
Protein	17.8	17.6	18.2	18.1	18.2	18.4	17.4
Calcium	1.92	1.94	1.94	1.85	1.61	1.60	1.57
Phosphorus	.83	.83	.85	.80	.70	.70	.68
Crude fiber	3.7	5.6	5.4	3.9	5.6	3.9	5.5
Fat	6.5	7.3	6.8	6.1	6.4	6.1	6.8

[1] Water enough to give the desired consistence should be added before feeding.

so-called fortified cod-liver oil is used, the quantity used should be such that it supplies at least 3,810 International Units of vitamin A and at least 540 units of vitamin D in each pound of mixed feed.

Finishing diets.—When it is desirable to feed finishing diets to broilers for a period of one or two weeks before they are to be marketed, diets of the type given in table 7 may be used.

In compounding the finishing diets given in table 7 either yellow or white corn may be used, but only white corn should be used, if yellow-fleshed birds are not desired; dried skim milk may replace dried buttermilk; and peanut oil, rapeseed oil, or red palm oil may be used instead of corn oil. In diets 15, 16, 17, and 18 meat scrap having a high free-fat-acid content should not be used. Diets 19, 20, and 21 tend to cause the skin of the chickens to become a deeper yellow; and if fed for 3 weeks or longer, the skin may acquire an orange-yellow color. Diet 18, however, does not have this effect but the other diets have it although to a less marked degree.

For finishing roasters, capons, and fowls[2] the diets need not contain so much protein as those for finishing broilers. A few diets for finishing roasters, capons, and fowls are given in table 8. In these diets dried skim milk may replace dried buttermilk; peanut oil, rapeseed oil, and red palm oil may be used in place of corn oil; and ground oyster

[2]See footnote on page 51.

Table 8. Finishing diets for roasters, capons, and fowls.

Ingredients	KIND AND PROPORTION OF FEEDS IN DIETS						
	Diet 22	Diet 23	Diet 24	Diet 25	Diet 26	Diet 27	Diet 28
	Parts by weight	Parts by weight	Parts by weight	Parts by weight	Parts by weight	Parts by weight	Parts by weight
Ground corn	46.8	43.8	26.8	.....	.....	.....	20.3
Finely ground barley	30.0	.....	.....	30.0	.....	35.2	.....
Finely ground oats	.....	34.0	30.0	.....	35.0	.....	35.0
Ground wheat	.....	.....	20.0	46.2	39.2	40.0	21.0
Corn gluten meal	.....	.....	.....	.....	5.2	4.0	4.0
Meat scrap	6.0	6.0	6.0	4.5	.....	.....	.....
Dried buttermilk	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Alfalfa leaf meal	.....	.....	.....	2.0	2.5	2.5	2.0
Corn oil	5.0	4.0	5.0	5.0	6.0	6.0	5.5
Ground limestone	1.7	1.7	1.7	1.8	1.8	1.8	1.7
Salt	.5	.5	.5	.5	.5	.5	5.
Water[1]							
ESTIMATED CONTENT OF VARIOUS NUTRITIVE CONSTITUENTS IN DIETS (DRY-FEED BASIS)							
	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent
Protein	14.5	14.5	15.0	15.5	14.8	14.7	13.9
Calcium	1.20	1.22	1.22	1.16	.82	.80	.77
Phosphorus	.59	.59	.61	.58	.41	.41	.39
Crude fiber	2.9	4.9	4.6	3.4	5.5	3.6	5.4
Fat	8.7	8.5	9.0	7.5	8.9	8.1	8.9

[1] Enough water to give the desired consistence should be added before feeding.

shell may be used instead of ground limestone. White corn and not yellow corn should be used, if yellow-fleshed birds are not desired.

Diet for segregated breeding males.—After segregated males are about 9 months old, the simplified all-mash diet given below may be fed. Any cereal grain, grain sorghum, or mixture of cereal grains or grain sorghums may be used in place of the yellow corn; dried buttermilk may be used instead of dried skim milk; and ground oyster shell will be as satisfactory as ground limestone.

Simplified all-mash diet for segregated breeding males (diet 29)

Ingredient	Parts by weight
Ground yellow corn	50.0
Wheat middlings	36.0
Dried skim milk	5.0
Alfalfa leaf meal	5.0
Linseed meal, old process	2.0
Ground limestone	1.3
Salt	.5
Cod-liver oil	.2
Total	100.0

Estimated content of various nutritive constituents in diet:

	Per cent
Protein	14.2
Calcium	.71
Phosphorus	.55
Fiber	4.4
Fat	4.1

Mash-Grain Diets

In using the mash-grain method of feeding, it should be remembered that inasmuch as the various grains are relatively poor sources of vitamin G, the mash should contain enough of this factor so that the combination of mash and grain will contain a sufficient supply of it. Likewise, when grains, other than yellow corn, are used, attention should be given to the vitamin A content of the mash. All mashes used in the mash-grain method of feeding should supply about twice as much vitamin D as those used in the all-mash method. Care must be taken also to insure that the combinations of mash and grain supply the proper quantities of calcium, phosphorus, and manganese.

Mashes for growing chickens.—The starting and growing mashes given in table 9 are intended for use when the mash-grain method of feeding is used. Finely cracked grain may be fed with these mashes any time after the chicks are 2 weeks old. Only a small quantity of grain should be fed at first but the quantity may be increased gradually until approximately equal quantities of mash and grain are being fed. Any suitable mixture of grains may be used, such as equal parts of corn and wheat, of corn and oat groats, or of corn, wheat, and oat groats. After the chickens are 8 to 10 weeks old, whole oats may be used instead of the oat groats.

In compounding the mashes given in table 9 any grain, grain sorghum, or mixture of grains or

grain sorghums may be used in place of the yellow corn; dried buttermilk may be used instead of dried skim milk; meat scrap, meat-and-bone scrap, and fish meal may be used interchangeably; cottonseed meal may be substituted for soybean meal; special alfalfa meal may be used instead of alfalfa leaf meal; ground oyster shell may be used in place of ground limestone; and sardine oil that contains at least 38,560 A. O. A. C. chick units of vitamin D per pound (85 A. O. A. C. chick units per gram) may be used instead of cod-liver oil.

Mashes for laying and breeding stock.—The laying mashes given in table 10 are intended for use only when the mash-grain method of feeding is used. For the best results, the mash and grain should always be fed in very nearly equal quantities. *Oyster shell or limestone grits should never be given to the chickens when these mashes are used.* Whole or cracked corn may be used as the so-called scratch grain but, if desired, mixtures of corn and oats; corn and wheat; corn, wheat, and oats; or mixtures containing the grain sorghums may be used.

Several substitutions may be made in mixing the mashes given in table 10. For example, dried buttermilk may be used in place of dried skim milk; meat scrap, meat-and-bone scrap, and fish meal may be used interchangeably; special alfalfa meal may be used in place of alfalfa leaf meal; ground oyster shell may be substituted for ground limestone; and sardine oil that contains at least

Table 9. Starting and growing mashes to be fed with grain.

Ingredient	KIND AND PROPORTION OF FEEDS IN MASHES						
	Mash 30	Mash 31	Mash 32	Mash 33	Mash 34	Mash 35	Mash 36
	Parts by weight	Parts by weight	Parts by weight	Parts by weight	Parts by weight	Parts by weight	Parts by weight
Ground yellow corn	17.7	18.9	26.3	25.3	26.8	17.5	.....
Ground wheat	.....	.....	.....	.....	23.0	.....	.....
Finely ground oats	10.0	12.0	.....	10.0	.....	.....	.....
Finely ground barley	.....	.....	.....	.....	.....	.....	46.3
Wheat middlings	20.0	12.0	35.0	20.0	.....	30.0	.....
Wheat bran	8.0	12.0	.....	.....	.....	10.0	.....
Dried skim milk	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Meat scrap	6.0	10.0	15.0	.....	10.0	5.0	8.0
Meat-and bone scrap	.....	.....	.....	5.0	.....	.....	.....
Fish meal	6.0	.....	.....	5.0	.....	4.0	.....
Alfalfa leaf meal	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Soybean meal	4.0	10.0	.....	.....	.....	4.0	.....
Corn gluten meal	.....	.....	.....	.....	13.0	4.0	15.0
Cottonseed meal	.....	.....	.....	10.0	.....	.....	.....
Linseed meal	3.0	.....	.....	.....	.....	.....	.....
Dried whey	.....	.....	.....	.....	2.0	.....	5.0
Ground limestone	1.3	1.1	1.7	1.7	0.7	2.0	0.7
Special steamed bonemeal	2.0	2.0	.....	1.0	2.5	1.5	3.0
Salt[1]	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Cod-liver oil	1.0	1.0	1.0	1.0	1.0	1.0	1.0
ESTIMATED CONTENT OF VARIOUS NUTRITIVE CONSTITUENTS IN MASHES							
	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent
Protein	22.6	22.4	22.1	22.1	22.2	22.4	22.5
Calcium	2.40	2.27	2.25	2.18	2.24	2.29	2.25
Phosphorus	1.20	1.13	1.12	1.10	1.11	1.17	1.13
Crude fiber	5.4	6.1	4.9	6.0	3.1	5.4	5.0

[1] The salt mixture given on page 44, or one containing about the same quantity of manganese, should be used in all the mashes given in this table.

Table 10. Laying mashes to be fed with grain.

Ingredient	KIND AND PROPORTION OF FEEDS IN MASHES						
	Mash 37	Mash 38	Mash 39	Mash 40	Mash 41	Mash 42	Mash 43
	Parts by weight	Parts by weight	Parts by weight	Parts by weight	Parts by weight	Parts by weight	Parts by weight
Ground wheat	.....	.....	.....	.....	39.1	.....	.....
Finely ground oats	17.5	19.0	.....	23.3	.....	.....	.....
Finely ground barley	.....	.....	.....	.....	.....	.....	39.0
Wheat middlings	15.0	15.0	49.4	20.0	.....	31.3	.....
Wheat bran	12.0	10.0	.....	.....	.....	20.0	.....
Dried skim milk	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Meat scrap	4.7	10.0	10.1	.....	10.0	4.5	10.0
Meat-and-bone scrap	.....	.....	.....	5.0	.....	.....	.....
Fish meal	4.7	.....	.....	5.0	.....	5.0	.....
Alfalfa leaf meal	14.0	15.0	16.0	15.0	13.0	12.0	12.0
Soybean meal	5.5	5.0	.....	5.3	.....	2.3	.....
Corn gluten meal	.....	.....	.....	.....	7.9	2.4	9.1
Linseed meal, old process	4.0	4.0	4.0	4.0	4.0	.....	4.0
Dried whey	.....	.....	.....	.....	3.5	.....	3.5
Ground limestone	5.9	5.6	6.5	5.3	4.8	6.8	4.9
Special steamed bonemeal	2.7	2.4	.....	3.1	3.7	1.5	3.5
Salt[1]	1.2	1.2	1.2	1.2	1.2	1.4	1.2
Cod-liver oil	2.8	2.8	2.8	2.8	2.8	2.8	2.8
ESTIMATED CONTENT OF VARIOUS NUTRITIVE CONSTITUENTS IN MASHES							
	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent
Protein	22.1	22.0	22.1	22.0	22.0	22.0	22.0
Calcium	4.32	4.25	3.89	4.36	4.30	4.24	4.26
Phosphorus	1.29	1.27	1.02	1.34	1.30	1.26	1.26
Crude fiber	7.3	7.5	6.5	7.4	3.9	6.3	5.2

[1] The salt mixture given on page 44, or one containing about the same quantity of manganese, should be used in compounding the mashes given in this table.

38,560 A. O. A. C. chick units of vitamin D per pound (85 A. O. A. C. chick units per gram) may be used instead of cod-liver oil.

USEFUL INFORMATION FOR FORMULATING DIETS

Much of the available information that will prove of value in formulating diets for chickens is given in the tables that follow. Some of the practical nutritive requirements of growing chicks, laying stock, and breeding stock are tabulated in table 11. Proximate chemical analyses of a number of feedstuffs used in feeding poultry are given in table 12. In view of the importance of calcium, phosphorus, and manganese in the feeding of chickens the average percentages of these elements found in some of the more commonly used feedstuffs are given in table 13. As an aid in checking the vitamin content of feed mixtures for chickens table 14 is presented. Data on the average digestibility of a few of the feedstuffs are given in table 15; all the data in this table were obtained from digestion experiments that were conducted with chickens.

Table 11. Summary of the requirements[1] of different classes of chickens for protein, minerals, and vitamins for satisfactory growth and development under the various conditions observed in practice.

Class	Protein[2] as proportion of total feed	Phosphorus as proportion of total feed	Calcium as proportion of total feed	Manganese in total feed	Vitamin A per pound of total feed[3]	Vitamin B per pound of total feed	Vitamin D per pound of total feed	Vitamin G (riboflavin) per pound of feed	Pantothenic acid (or the chick antidermatosis factor) per pound of total feed
	Per cent	Per cent	Per cent	Parts per million	International Units	International Units	A.O.A.C. chick Units	Micrograms (or gammas)	Modified Jukes-Lepkovsky units[4]
Growing chicks ..	21	0.7	1.1	50	1,450	180	180	1,670	0.9
Laying stock.....	16	1.0	2.4	50	3,150	180	360	680	0.9
Breeding stock....	16	1.0	2.4	50	4,720	180	540	1,250	0.9-1.0
Segregated breeding males[5].....	13	0.4	0.5	....	1,200	180	75	550	.....

[1] Consult the text for more complete statements of the protein, mineral, and vitamin requirements.
[2] The protein must be of reasonably good quality; and it is desirable that not less than 20 per cent of it be derived from animal sources.
[3] If the feed is to be stored for more than a month before it is fed, at least 90 per cent of the vitamin A should be derived from plant sources.
[4] The modification consists in giving the same value to a pound of the feedstuff as was originally given to a gram.
[5] After about 9 months of age.

Table 12. The average composition of some feedstuffs used in the feeding of poultry.

Feedstuff	Moisture	Ash	Crude protein	Carbohydrates		Fat, or ether extract
				Crude fiber	Nitrogen-free extract	
Grains and seeds	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent
Barley	10.4	2.9	11.8	5.9	66.9	2.1
Barley (Pacific Coast States)	10.1	2.6	8.7	5.7	71.0	1.9
Beans, navy	13.4	3.6	22.7	5.8	53.0	1.5
Beans, pinto	9.1	4.5	22.7	4.5	58.0	1.2
Bread	33.8	1.5	7.9	.7	55.4	.7
Brewers' grains, dried	7.0	3.7	26.2	14.7	41.8	6.6
Broom corn	11.6	3.1	10.5	8.3	63.0	3.5
Buckwheat	11.9	1.8	10.1	10.4	63.5	2.3
Buckwheat middlings	11.4	4.7	28.6	6.0	42.2	7.1
Coconut meal, old process	9.3	6.1	20.5	11.1	44.7	8.3
Corn	11.9	1.3	9.3	2.1	71.2	4.2
Corn, Argentine	11.0	1.7	11.0	1.8	68.8	5.7
Corn bran	9.9	2.3	9.9	9.6	61.6	6.7
Corn meal	11.2	.9	8.8	1.1	75.5	2.5
Corn gluten feed	9.7	6.1	25.9	7.2	48.5	2.6
Corn gluten meal	8.9	1.5	43.0	2.6	42.1	1.9
Cottonseed meal (41 per cent protein)	7.5	5.8	41.8	11.4	27.1	6.4
Cowpeas	11.1	3.5	23.5	4.1	56.3	1.5
Distillers' grains (corn), dried	7.0	2.3	31.2	11.5	37.5	10.5
Durra	10.0	2.0	10.2	1.7	72.6	3.5
Feterita	10.2	1.6	13.2	1.8	70.2	3.0
Field peas	9.3	3.3	23.3	5.9	57.0	1.2
Flaxseed	10.3	4.4	22.3	7.1	23.1	32.8

Garden peas	11.8	3.0	25.6	4.4	53.6	1.6
Hempseed	7.6	5.9	22.9	18.6	18.4	26.6
Hempseed meal	7.3	7.8	31.7	23.9	25.3	4.0
Hominy (pearled)	11.8	.7	7.4	.6	77.6	1.9
Hominy feed	8.8	2.9	11.0	5.1	65.5	6.7
Kafir	11.7	1.6	11.5	2.0	70.1	3.1
Linseed meal, old process	9.4	5.8	35.3	8.5	35.0	6.0
Malt sprouts	7.9	5.9	26.0	13.0	45.7	1.5
Millet (proso)	9.6	3.4	11.6	8.7	63.1	3.6
Milo	11.0	2.0	11.0	2.2	70.9	2.9
Oats	10.1	3.4	11.2	11.3	59.5	4.5
Oatmeal, or rolled oats	8.6	2.2	16.2	2.1	64.2	6.7
Peanuts (hulls on)	6.0	2.8	24.8	17.8	14.0	34.6
Peanut kernels	5.4	2.3	30.4	2.7	11.6	47.6
Peanut meal (no hulls), old process	6.9	5.6	45.7	9.2	24.0	8.6
Rice (whole)	10.3	4.7	7.9	8.8	66.3	2.0
Rice (polished)	11.8	.5	7.5	0.4	79.4	0.4
Rice bran	8.8	10.9	13.0	12.5	41.1	13.7
Rye	10.7	2.0	11.5	2.1	72.0	1.7
Soybeans	8.8	4.8	37.9	5.0	26 6	16.9
Soybean meal	9.1	5.6	43.9	5.9	30 0	5.5
Shallu	10.0	1.8	12.9	1.8	70.0	3.5
Sunflower seed	7.4	3.4	16.0	28.6	21.4	23.2
Sunflower seeds (hulled)	5.0	3.8	28.0	6.0	16.2	41.0
Velvet beans	10.0	3.0	24.8	6.2	50.8	5.2
Wheat	11.0	1.8	12.4	2.4	70.5	1.9
Wheat bran	10.2	5.9	15.6	9.0	55.1	4.2
Wheat flour	12.9	.4	10.7	.4	74.2	1.4
Wheat flour middlings	10.5	3.5	17.0	5.1	59.3	4.6
Wheat germ meal	8.7	4.6	28.9	2.7	44.7	10.4
Wheat middlings, standard	11.1	4.1	16.9	6.6	56.6	4.7
Wheat red dog flour	10.2	2.7	16.9	3.2	62.6	4.4
Wheat shorts (gray)	10.3	4.1	17.6	5.5	58.0	4.5

Table 12 (continued)

Feedstuff	Moisture	Ash	Crude protein	Carbohydrates		Fat, or ether extract
				Crude fiber	Nitrogen-free extract	
Feeds of animal origin	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent
Beef scrap	6.5	21.5	58.0	2.2	0.7	11.1
Bonemeal, steamed	3.1	73.8	13.0	.8	2.8	6.5
Bonemeal, special steamed	3.1	85.1	6.5	2.6	2.1	.6
Buttermilk	90.8	.8	3.2	.0	4.6	.6
Buttermilk, condensed	71.6	3.5	10.6	.0	12.2	2.1
Buttermilk, dried	7.1	10.1	33.4	.4	44.0	5.0
Crab meal	8.1	40.1	34.7	8.5	6.5	2.1
Fish meal (average of unidentified fishmeals)	8.0	19.7	60.4	.7	3.5	7.7
Fish meal, herring	9.1	12.1	66.0	.6	3.0	9.2
Fish meal, menhaden	8.0	20.4	57.5	.8	4.1	9.2
Fish meal, white (high ash)	7.8	26.0	61.6	.4	1.2	3.0
Fish meal, white (low ash)	12.1	17.6	60.9	.6	.1	8.7
Fish meal, sardine	8.0	15.0	67.0	.4	3.6	6.0
Fish meal, tuna	5.0	20.2	60.7	.4	5.1	8.6
Liver meal, Argentine	5.0	5.0	65.4	.8	9.8	14.0
Meat scrap (55 per cent protein)	6.7	24.2	55.2	2.2	1.0	10.7
Meat-and-bone-scrap (50 per cent protein)	6.0	29.2	50.0	2.1	1.8	10.9
Pork liver, dried	4.8	5.3	63.7	.4	15.0	10.8
Pork cracklings	5.0	2.3	56.4	.0	4.1	32.2
Shrimp meal (or bran)	11.0	33.9	42.0	9.5	1.4	2.2
Skim milk	90.5	.7	3.5	.0	5.1	.2
Skim milk, dried	6.0	7.9	35.0	.0	50.0	1.1
Tankage (60 per cent protein)	8.0	19.5	59.8	2.7	1.8	8.2

Whey	93.7	.6	.8	.0	4.9	.0
Whey, dried	6.3	8.5	12.5	.3	71.7	.7
Green Feeds, etc.						
Alfalfa, fresh, green	73.8	2.5	4.6	7.5	10.7	.9
Alfalfa leaf meal	7.8	12.0	20.4	17.1	40.1	2.6
Alfalfa meal	8.3	8.7	16.0	27.3	37.2	2.5
Beet pulp, dried	9.0	3.3	9.3	19.1	58.5	.8
Cabbage	90.8	.8	1.8	1.1	5.2	.3
Cane molasses, liquid	24.8	8.2	3.0	.0	64.0	.0
Cane molasses, dried	4.9	10.1	5.0	.2	79.3	.5
Carrots	88.4	1.1	1.1	1.2	7.9	.3
Grape fruit refuse, dried	9.3	4.3	4.8	11.6	68.7	1.3
Kale	88.4	1.9	2.4	1.5	5.3	.5
Mangels	90.1	1.1	1.5	.8	6.4	.1
Orange peel, dried	14.0	4.1	5.8	10.6	64.8	.7
Orange pulp meal	10.8	3.4	7.5	8.9	67.9	1.5
Potatoes	78.8	.9	2.0	.5	17.7	.1
Rape	84.6	2.2	2.6	2.4	7.6	.6
Red-clover hay	12.3	6.7	12.7	25.7	39.6	3.0
Rutabagas	88.8	1.0	1.2	1.5	7.3	.2
Turnips	90.6	.8	1.3	1.1	6.0	.2
Yeast, brewers', dried	7.0	7.3	46.5	1.1	35.3	2.8

Table 13. The average calcium, phosphorus and manganese content of some feedstuffs used in the feeding of poultry.

Feedstuffs	Calcium (Ca)	Phosphorus (P)	Manganese (Mn)
Grain and Seeds	Per cent	Per cent	Parts per million
Barley	0.05	0.36	16
Beans, navy	0.16	0.45	13
Bread	0.03	0.10	4
Brewer's grains, dried	0.20	0.46	20
Buckwheat	0.06	0.43	80
Coconut meal, old process	0.29	0.64	85
Corn	0.01	0.29	5
Corn bran	0.03	0.20	16
Corn-gluten feed	0.13	0.64	24
Corn-gluten meal	0.06	0.40	4
Corn meal	0.01	0.30	4
Cottonseed meal (41 per cent protein)	0.23	1.18	18
Cowpeas	0.10	0.46	30
Distillers' grains (corn), dried	0.04	0.30	20
Feterita	0.02	0.32	*
Field peas	0.08	0.40	30
Flaxseed	0.25	0.66	35
Garden peas	0.08	0.40	30
Hempseed meal	0.22	0.87	*
Hominy	0.01	0.08	2
Hominy feed	0.03	0.51	16
Kafir	0.03	0.35	16
Linseed meal, old process	0.33	0.74	40
Malt sprouts	0.18	0.70	35
Millet (proso)	0.01	0.33	35
Milo	0.04	0.32	15
Oats	0.10	0.36	34
Oatmeal, or rolled oats	0.08	0.44	20
Peanut kernels	0.07	0.39	16
Peanut meal, old process	0.18	0.56	18
Rice (polished)	0.01	0.09	12
Rice bran	0.10	1.84	280
Rye	0.05	0.36	40
Soybeans	0.20	0.53	31
Soybean meal	0.29	0.69	30
Sunflower seed	0.41	0.99	*
Wheat	0.04	0.39	39
Wheat bran	0.11	1.21	119

Table 13 (continued)

Feedstuffs	Calcium (Ca)	Phosphorus (P)	Manganese (Mn)
Grain and Seeds	Per cent	Per cent	Parts per million
Wheat flour	0.02	0.11	4
Wheat flour middlings	0.07	0.69	113
Wheat germ meal	0.07	1.01	160
Wheat middlings, standard	0.08	0.93	119
Wheat red dog flour	0.07	0.59	35
Wheat shorts	0.08	0.93	60
Feeds of animal origin			
Beef scrap	7.23	3.73	5
Buttermilk, liquid	0.18	0.10	Trace
Buttermilk, condensed	0.56	0.33	0.2
Buttermilk, dried	1.56	1.05	0.04
Crab meal	13.25	0.50	*
Fish meal (average of unidentified fish meals)	6.50	3.60	45
Fish meal, herring	3.83	2.50	*
Fish meal, white (high ash)	9.09	4.70	*
Fish meal, white (low ash)	5.84	3.04	*
Fish meal, sardine	4.73	2.63	40
Fish meal, tuna	6.25	3.46	*
Liver meal, Argentine	0.11	0.90	4
Meat-and-bone scrap (50 per cent protein)	10.20	4.91	10
Meat scrap (55 per cent protein)	8.25	4.00	18
Pork liver, dried	0.06	1.12	4
Skim milk, liquid	0.13	0.11	Trace
Skim milk, dried	1.27	0.96	0.6
Tankage (60 per cent protein)	7.16	3.53	14
Whey, liquid	0.05	0.04	1
Whey, dried	0.83	0.70	14
Green feeds, etc.			
Alfalfa, fresh, green	0.42	0.07	7
Alfalfa leaf meal	1.90	0.22	30
Alfalfa meal	1.44	0.21	26
Beet pulp, dried	0.70	0.07	23
Cabbage	0.07	0.04	21
Cane molasses, liquid	0.56	0.06	*

Table 13 (continued)

Feedstuffs	Calcium (Ca)	Phosphorus (P)	Manganese (Mn)
	Per cent	Per cent	Parts per million
Cane, molasses, dried	1.12	0.08	*
Carrots	0.06	0.07	*
Grapefruit refuse, dried	0.74	0.10	*
Kale	0.18	0.07	*
Orange peel, dried	0.73	0.11	8
Orange pulp meal	0.64	0.10	*
Potatoes	0.02	0.06	3
Rape	0.34	0.07	50
Red-clover hay	1.17	0.18	40
Rutabagas	0.06	0.04	*
Turnips	0.05	0.05	*
Yeast, dried	1.26	1.21	2
Calcium, phosphorus, and manganese supplements			
Bone, fresh	22.95	10.42	12
Bonemeal	27.00	13.00	13
Bonemeal, steamed	28.80	13.34	5
Bonemeal, special steamed	31.30	14.49	2
Crab shell	23.74	2.55	300
Gypsum	25.00	Trace	*
Limestone, high-calcium	39.20	0.00	200
Oyster shell, washed	38.00	Trace	100
			Per cent
Manganous sulphate, anhydrous	0.00	0.00	36.3
Manganous sulphate, tetrahydrate	0.00	0.00	24.6

*Information lacking.

Table 14. The average vitamin content of some feedstuffs used in the feeding of poultry.

Feedstuff	Vitamin A per pound	Vitamin B_1 per pound	Vitamin D per pound[1]	Vitamin E[2]	Vitamin G (riboflavin) per pound	Pantothenic acid (or the chick antidermatosis factor) per pound[5]
Grain and seeds	International Units	International Units	A.O.A.C. chick Units[3]		Micrograms (gammas)[4]	Modified Jukes-Lepkovsky Units[5]
Barley	400	400	Trace	++	400	0.7
Beans, navy	*	500	.....	*	*	0.1
Beans, pinto	*	2,270	.....	*	*	*
Bread	50	40	.....	*	*	*
Buckwheat	*	500	.....	*	300	*
Corn, yellow	3,180	400	.....	++	400	0.7
Corn, white	0	450	.....	++	400	0.7
Corn gluten meal (yellow)	6,800	*	.....	0	0	*
Cottonseed meal (41 per cent protein)	600	1,800	.....	*	300	1.0
Cowpeas	450	1,200	.....	*	350	1.3
Distillers' grains, dried	500	300	700(?)	*	1,000	*
Field peas	2,720	1,200	.....	*	*	*
Garden peas	4,540	900	.....	++	*	1.5
Hempseed meal	*	*	.....	++	1,100	1.0
Kafir	250	380	.....	*	*	*
Linseed meal, old process	200	2,000	.....	+	900	0.1
Milo	250	*	.....	*	400	0.7
Oats	80	1,200	.....	++	400	0.7
Oat meal, or rolled oats	*	1,000	.....	++	500	0.8
Peanuts (hulls on)	*	900	.....	++	950	3.5
Peanut kernels	*	1,200	.....	++	1,200	4.0

Feedstuff	Vitamin A per pound	Vitamin B[1] per pound	Vitamin D per pound[1]	Vitamin E[2]	Vitamin G (riboflavin) per pound	Pantothenic acid (or the chick antidermatosis factor) per pound[5]
	International Units	International Units	A.O.A.C. chick Units[3]		Micrograms (gammas)[4]	Modified Jukes-Lepkovsky Units[5]
Peanut meal, no hulls, old process	250	900	.....	++	1,200	4.0
Rice bran	*	1,500	.....	*	900	1.8
Rye	*	450	.....	++	*	*
Soybeans	500	2,000	.....	*	1,200	1.0
Soybean meal	170	1,600	Trace	*	1,500	1.0
Wheat	750	680	.....	++	400	0.7
Wheat bran	150	840	.....	++	750	1.8
Wheat flour	*	60	.....	*	150	*
Wheat germ meal	1,900	1,930	.....	++++	1,800	0.5
Wheat flour middlings	100	800	.....	++	600	0.7
Wheat middlings, standard	120	1,000	.....	+++	900	0.8
Wheat red dog flour	60	180	.....	*	450	*
Wheat shorts	180	1,000	.....	+++	900	0.8
Feeds of animal origin						
Buttermilk, liquid	25	50	*	*	1,000	0.3
Buttermilk, dried	200	450	Trace	+	9,000	3.0
Buttermilk, sweet cream, dried	200	450	Trace	+	12,000	3.0
Cod-liver oil	385,550[6]	0	38,560[6]	0	0	0
Cod-liver oil, fortified	1,362,000	0	181,600	*	0	0
Fish meal, white	*	140	*	*	4,200	0.2

Fish meal, sardine	*	140	*	*	3,200	0.2
Fish meal, menhaden	*	*	*	*	2,250	0.2
Liver meal, Argentine	*	350	*	*	18,500	8.0
Meat scrap	*	180	.....	*	3,000	0.2
Pork liver, dried	47,670	500	200	*	40,000	10.0
Sardine (pilchard) oil	52,000	0	38,560	*	0	0
Skim milk, liquid	15	50	.....	+	1,000	0.3
Skim milk, dried	130	500	.....	+	9,000	2.5
Tankage	*	150	.....	*	800	*
Whey, dried	*	500	.....	*	10,000	4.0
Green feeds, etc.						
Alfalfa, fresh, green	63,560	225	.....	++	2,000	0.8
Alfalfa leaf meal, dehydrated	95,000	450	.....	+++	8,000	3.0
Alfalfa leaf meal	32,000	400	14	+++	7,000	2.0
Alfalfa meal	13,000	400	.....	+++	5,000	1.5
Cabbage	450	100	.....	*	100	*
Cane molasses	*	*	.....	*	2,000	6.0
Carrots	18,200	100	.....	*	120	0.1
Distillers' slop, condensed	500	800	*	*	1,250	*
Kale	45,000	250	.....	*	2,240	*
Potatoes	220	200	.....	*	55	*
Red-clover hay	9,000	450	.....	+++	*	*
Turnips	*	90	.....	*	45	*
Yeast, brewers', dried	*	4,500	.....	0	16,000	15.0

See footnotes on next page.

*Information on vitamin content is lacking.

[1] Leaders ..... mean that the feedstuff contains no appreciable quantity of vitamin D.

[2] Symbols in this column have the following meanings: +Fair source of vitamin E; ++Good source of vitamin E; +++Very good source of vitamin E; ++++Excellent source of vitamin E.

[3] This is the official unit of the Association of Official Agricultural Chemists. It is equivalent to 1 International Unit of the kind of vitamin D in pure cod-liver oil.

[4] A microgram, or gamma, is one millionth of a gram. It is equal to approximately one twenty-eight millionth of an ounce.

[5] The modification consists in giving the same value to a pound of the feedstuff as was originally given to a gram.

[6] Cod-liver oil, if it is to be sold legally as such in interstate commerce, must contain after July 1, 1940, at least 385,550 International Units of Vitamin A and 38,560 International Units (or A.O.A.C. chick units) of vitamin D per pound. The vitamin A content of cod-liver oil varies from 385,550 to about 1,000,000 International Units per pound and the vitamin D content from 38,560 to about 160,000 International Units per pound. Cod-liver oil and other vitamin-bearing fish oils should be purchased only from reliable sources and should be used according to the manufacturer's guarantee of their potency.

Table 15. Average digestibility in the chicken of some feedstuffs used in the feeding of poultry.

Feedstuff	Organic matter	Crude protein	Crude fiber	Nitrogen-free extract	Fat, or ether extract	Total digestible nutrients
Grains and seeds	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent
Barley	76	75	7	83	62	68
Buckwheat	72	59	8	85	87	65
Corn, whole or cracked	87	76	12	90	86	80
Corn, ground	88	79	6	92	88	81
Corn meal	87	74	7	90	89	80
Corn, Argentine, whole or cracked	88	84	16	91	81	83
Corn, Argentine, ground	88	83	13	91	91	84
Cottonseed meal	72	76	12	86	86	69
Cowpeas	75	55	12	87	89	65
Feterita	89	88	33	91	81	82
Field peas	74	76	12	80	80	66
Garden peas	83	88	10	86	86	72
Kafir	90	84	19	93	80	81
Millet	78	76	17	87	78	72
Milo	89	83	31	92	78	80
Mixed feed (laying mash)	85	85	44	88	92	83
Oats	66	74	12	74	84	62
Oatmeal, or rolled oats	87	79	14	91	92	85
Rice, whole	74	75	5	84	72	65
Rice bran	52	60	3	52	87	41
Rye	79	68	8	84	27	60
Soybeans	79	74	20	93	86	86

Table 15 (continued)

Feedstuff	Organic matter	Crude protein	Crude fiber	Nitrogen-free extract	Fat, or ether extract	Total digestible nutrients
Grains and seeds	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent
Soybean meal	77	83	2	82	82	71
Shallu	90	78	39	94	85	83
Wheat	82	75	8	87	50	73
Wheat bran	46	66	9	47	42	41
Wheat middlings	54	65	8	55	54	48
Wheat shorts	68	69	13	71	85	63
Feeds of animal origin						
Beef scrap	90	92	....	....	94	77
Buttermilk, dried	81	82	....	81	78	72
Fish meal	90	91	....	....	94	71
Meat scrap and meat-and-bone meal	87	90	....	....	93	70
Skim milk, dried	87	90	....	85	95	76
Tankage	85	85	....	....	96	69
Green feeds, etc.						
Alfalfa-leaf meal	30	99	4	....	....	....
Alfalfa meal	29	64	2	34	22	25
Beet pulp, dried	17	37	0	19	0	15
Potatoes	75	47	6	84	....	16
Clover hay	23	71	10	14	36	20